OPERATION & MAINTENANCE

HANDBOOK

MODEL 109
PULSE GENERATOR

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DATAPULSE®

A SUBSIDIARY OF SYSTRON-DONNER CORPORATION

OPERATION & MAINTENANCE

HANDBOOK

MODEL 109
PULSE GENERATOR

DATAPULSE
A Subsidiary of Systron-Donner Corporation
10150 W. JEFFERSON BLVD., CULVER CITY, CALIF. 90230

MODEL 109 40 Mc PULSE GENERATOR

The Datapulse 109 Pulse Generator is an economical source of very fast rise time pulses at very high repetition rates. Wide range controls also allow general purpose application down to such low speed requirements as relay testing biophysical research, and sonic delay generation.

This manual contains general and detailed instructions for operation and maintenance of your Model 109. A complete understanding of its contents will contribute greatly to full utilization of the broad capabilities of this instrument.

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SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

Continuously variable from 4 cps to 40 mc, covered in six decade ranges. Maximum rate on Double Pulse Mode is 20 mc.

1.2 EXTERNAL TRIGGER

Operates at 0-40 mc (20 mc maximum on Double Pulse Mode) from ±1.5v pulses with rise time less than 20 nanosec and duration greater than 20 nsec (requires greater amplitude for slower rise times or lesser duration). Sensitivity control is provided to allow adjustment for noise rejection. Input impedance may be selected by panel switch as 50 ohms or 500 ohms. Maximum dc level or transient amplitude which may be applied is ±25v with sensitivity control at maximum.

1.3 SINGLE CYCLE

Operation of a front panel pushbutton provides one cycle (single or double pulse as selected) of output.

1.4 GATED OPERATION

The oscillator or external trigger input are logically gated to the main pulse forming circuits. Main pulse outputs are blocked by a gate of +3.5v or more without inhibition of the sync pulse. No connection or levels of zero or less, enable outputs. Input resistance is approx. 1000 ohms. Levels greater than ±25v may not be applied.

1.5 SYNC OUTPUT

Negative 4v from 50 ohms (2v into 50 ohms), approximately 20 nsec duration, approximately 5 nsec rise and fall time with 50 ohm load. Sync occurs approximately 65 nsec after external trigger if used.

1.6 PULSE MODES

Single Pulse or Double Pulse, selected by panel toggle switch. In the Double Pulse Mode, two main pulses are provided at the output during each cycle (essentially identical in width, amplitude, polarity, rise time, and fall time), one approximately 10 nsec before the Sync Output and the second at a position determined by the pulse delay controls.

1.6.1 Main Pulse Delay, Single Pulse Mode (of leading edge from sync output).

Continuously variable from approximately 10 nsec advance to 50 ms delay, covered in six decade ranges plus 10 to 50 nsec range. Maximum delay duty cycle is typically 85%, decreasing to at least 50% at 30mc and 40% at 40mc repetition rate.

1.6.2 First Pulse Position, Double Pulse Mode.

Leading edge occurs approximately 10 nsec before Sync Output.

1.6.3 Pulse Separation, Double Pulse Mode.

Leading edge of first pulse to leading edge of second pulse is continuously variable by means of Pulse Delay controls from 25 nsec to 50 ms. Minimum trailing edge to leading edge separation is approximately 30% of pulse width or 15 nsec, whichever is greater.

1.7 PULSE DURATION

Continuously variable from 10 nsec to 50 ms, covered in six decade ranges plus 10 to 50 nsec range. Maximum duty cycle is typically 85%, decreasing to at least 50% at 30mc and 40% at 40mc.

1.8 JITTER

Repetition rate jitter is less than 0.05%. Delay and width jitter is less than 0.1%.

1.9 MAIN PULSE OUTPUT

Positive and negative outputs are provided simultaneously. Outputs are dc coupled with baseline at ground.

1.9.1 Peak Amplitude (Separately Controlled for Positive and Negative Outputs).

Continuously variable from less than 1v to 10v into 50 ohms.

1.9.2 Rise and Fall Times (With 50 ohm Resistive Load).

Less than 5 nsec. Type 2401 Rise Time Integrator accessory available allows variable rise time control (exponential waveform) from 5 to 60 nsec, also controlling fall time but with lesser effect, with approximately 2 db (20%) insertion loss.

1.9.3 Waveform Aberrations (With Properly Connected 50 Ohm Load).

Overshoot, undershoot, ring, and top slope are less than 5% at amplitudes of 3v and higher.

1.9.4 Output Protection.

Output stages will not be damaged by any combination of panel control settings, short circuits of any duration, or back voltages up to ±10v.

1.9.5 Output Mixing.

Positive and/or negative outputs of multiple units may be directly mixed with each other or with other outputs (±10v max.). Mixed outputs add approximately algebraically to a maximum of 10v.

1.10 OPERATING TEMPERATURE

The unit is rated for operation at ambient temperature of 0° to 50°C.

1.11 POWER REQUIRED

105v to 125v, 50/60 cycle ac. approximately 50 watts. 220v operation may be specified at no added cost.

1.12 PHYSICAL

Aluminum panel with etched red and black markings, beige cabinet with quick-release top and bottom covers. BNC signal connectors. 5 1/2" H x 17" W x 15 1/4" D; approximately 30 lbs.

May be rack mounted (5 1/4" H x 19" W panel space) by specifying Model 109R, or by installing Type 1003 Rack Mounting Set.

1.13 ACCESSORIES FURNISHED

One operation and maintenance manual, 8 ft. line cord with NEMA 3-prong plug.

1.14 ACCESSORIES AVAILABLE

Type 2401 Rise Time Integrator (adds variable rise and fall control); Type 2201 Mixer (for best waveform when mixing same polarity outputs of two units); Type 2003 Termination, 50 ohm, 25w; Type 1003 Rack Mounting Set, and extra instruction manuals.

SECTION II

OPERATING INSTRUCTIONS

2.1 DESCRIPTION OF CONTROLS AND CONNECTORS

2.1.1 Power Switch

Connects or disconnects ac input voltage to transformer primaries within instrument.

2.1.2 Pilot Lamp

Lights when power is ON.

2.1.3 Repetition Rate

The black outer knob selects Repetition Rate Range. There are six ranges, each covering one decade of frequency. One position is provided for single pulse operation; one position for external triggering with positive going waveforms, and one position for triggering with negative going waveforms.

2.1.4 Repetition Rate Verniers

The inner red knob on the Repetition Rate Control provides continuous fill-in between 4 cps and 4 mc. In the 40 mc range, fill-in is provided by the 4mc-40mc vernier (black knob). The two verniers are automatically switched in and out by the Repetition Rate Control.

2.1.5 Single Cycle Button

This control provides one cycle of operation for each depression of the pushbutton. To operate, the Repetition Rate Control must be turned to the Single Cycle position.

2.1.6 Pulse Mode Switch

Single or Double Pulse Mode selected by front panel toggle switch. In the Double Pulse Mode, two main pulses are provided at the output during each cycle (identical in width, amplitude, polarity, rise time, and fall time), one approximately coincident with the Sync Output and the second at a position determined by the pulse delay controls.

2.1.7 External Trigger Input Jack

BNC connector accepts a pulse or sine wave to slave oscillator to outside signal with Repetition Rate Control in EXT position.

2.1.7.1 Trigger Input Impedance Switch This switch determines whether the input impedance of the EXT. Trigger Circuit is 50 ohms or 500 ohms. For fast rise time or high frequency input signals, use 50 ohm coaxial cable to bring the signal to the EXT Trigger Input Jack and put the switch to the 50 ohm position. For slow signal, put the switch to the 500 ohm position to minimize loading of the signal.

2.1.8 External Sensitivity

Adjusts the level on an external signal at which the oscillator triggers.

WARNING

Maximum dc level or transient amplitude which may be applied is ±25v with sensitivity control at maximum.

2.1.9 Negative Sync Output Jack

The Negative Sync Output is taken from this BNC jack. Because of the fast rise time of the Sync Output Signal, a 50 ohm coaxial cable should be used to convey the signal. For reliable operation, the signal should be terminated into a 50 ohm load.

2.1.10 Gate Input

This BNC connector provides input for an external gating signal. When dc level of signal is more positive than +3.5v, output pulses are disabled.

WARNING

Maximum is ±25v.

2.1.11 Pulse Delay Control

The black outer knob selects the delay range. There are seven ranges of which the last six are decades. The first range is quinary and provides coverage from 10 nanosec to 50 nanosec.

2.1.12 Pulse Delay Vernier

The red inner knob provides continuous fill-in between ranges of the pulse delay control. With this control fully clockwise the instrument is calibrated at the delay shown by the Pulse Delay Control.

2.1.13 Pulse Width Control

The black outer knob selects the width range. There are seven ranges covering 10 nsec to 50 milliseconds.

2.1.14 Pulse Width Vernier

The red inner knob provides continuous fill-in between ranges of the Pulse Width Control. With this control fully clockwise the instrument is calibrated at the width shown by the Pulse Width Control.

2.1.15 Positive and Negative Amplitude Controls

These are constant impedance, 50 ohm,

attenuators continuously variable from zero to over 20 db. There will be some deterioration of pulse shape at greater than 100 db attenuation. For best operation, it is recommended that external attenuators be used for attenuations over 10 db.

2.2 PLACING IN OPERATION

2.2.1 Preliminary Settings

a. Set Repetition Rate Control to 400 kc, Vernier cw.

b. Set Pulse Mode Switch to single pulse position.

c. Set Pulse Delay Control to 0.5μs, Vernier ccw.

d. Set Pulse Width Control to 0.5μs, Vernier cw.

e. Set Positive Amplitude Control to cw.

f. Set Negative Amplitude Control to cw.

g. Turn Power Switch ON. Pilot lamp should light.

h. Trigger scope from Negative Sync Output. Set Scope Sweep to 0.1μs/cm, Vertical Sensitivity to 5v/cm.

i. Load Positive Output Pulse into 50 ohms. Compare output with that shown in Figure 2-1.

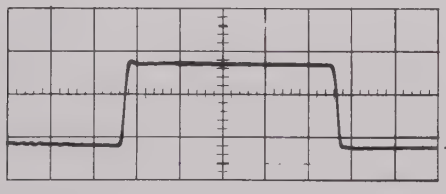


Figure 2-1. Positive Output Into 50 Ohms. 0.1μs/cm, 5v/cm. Tektronix 541A.

j. Load Negative Output Pulse into 50 ohms. Compare output with that shown in Figure 2-2.

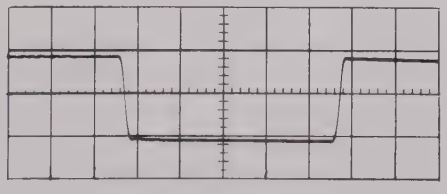


Figure 2-2. Negative Output Into 50 Ohms. 0.1μs/cm, 5v/cm. Tektronix 541A.

k. Vary the Pulse Delay Vernier. The leading edge of the pulse should vary and the pulse width should remain constant.

l. Vary the Pulse Width Vernier. The Output Pulse width should vary and the pulse delay should remain constant.

m. Vary the Amplitude Controls. The amplitude of the pulses should vary. Pulse aberration should not increase significantly until the amplitude of the pulses have decreased to less than 3v.

n. If instrument fails to function properly, refer to Troubleshooting section of manual.

2.3 OPERATING CONSIDERATIONS

2.3.1 External Triggering

When the Repetition Rate Control is in the -EXT or the + EXT position, the Model 109 can be driven from an external source provided that the driving signal is greater than 1.5v in amplitude and 20 nanosec in width. The rise time of the external signal must be less than 20 nanosec; for slower rise time signals, the amplitude must be increased (up to a maximum of 3.5v for rise times of 1μsec or slower). In the -EXT position, the circuit will trigger on the negative going slope of the input waveform; in the +EXT position, the circuit triggers on the positive going waveform.

When externally driving the Model 109, always set the sensitivity control to the full counter-clockwise position before application of the driving waveform. This will insure than no damage will be done to the Schmitt trigger should the driving waveform be greater than ±25v in amplitude. With the external signal applied to the external trigger input jack and the sensitivity control in the ccw position, adjust the sensitivity clockwise until stable triggering is obtained. Do not advance the sensitivity control any more than is necessary as the lowered input impedance and attendant overdrive may cause severe distortion of the input signal which can result in unstable multiple triggering of the Model 109.

WARNING

Always insure that the driving signal is less than ±25v when the sensitivity control is in the maximum (clockwise) position to avoid damage to the Schmitt trigger circuit.

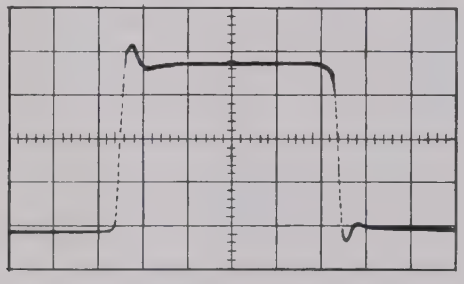
When the external driving signal is less than 0.1μs in rise time or greater than 1 mc in frequency, it should be conveyed to Model 109 by means of a 50 ohm coaxial cable. The input impedance switch should then be set to the 50 ohm position to properly terminate the coaxial cable. For slower driving signals, the input impedance can be set to 500 ohms to minimize loading. When externally triggering the Model 109 above 5 mc, the Input Sensitivity Control may have to be readjusted as the frequency of the driving signal is changed.

2.3.2 Duty Cycle Limitations

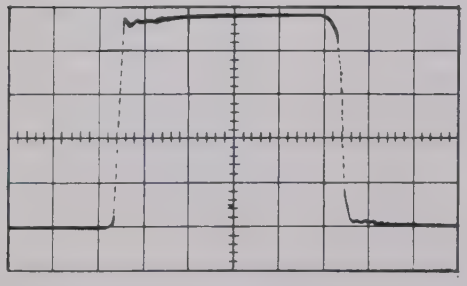
At duty cycles greater than 70%, the pulse delay and width one shot multivibrators may fail. There are no average current or power limitations imposed on the Model 109; however, under excessive duty cycle conditions instability and severe amplitude reductions occur. In order to minimize confusion and inaccurate data which will most certainly result from excessive duty cycle, it is recommended that the delay and width controls be set to their minimum position when frequency is being changed, and then reset to the desired settings upon completion of frequency shift. In this manner it is highly improbable that duty cycle rating will be exceeded while the frequency control is adjusted.

2.3.3 Output Characteristics

2.3.3.1 Amplitude Control: The outputs of the current drivers are coupled to their respective BNC connectors by the use of constant impedance attenuators. Each output has an independent attenuator providing over 20 db of useful attenuation. For minimum distortion of output pulses, the attenuators should not be adjusted for more than 10 db of attenuation. See Figure 2-3 a. For attenuations greater than 10 db, external coaxial attenuators should be used. See Figure 2-3 b.



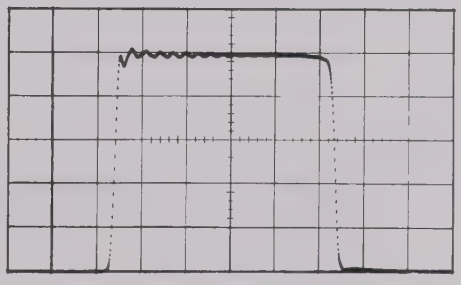
a. Positive Output Pulse Attenuated to 1v (20 db) Using Internal Amplitude Control Only.



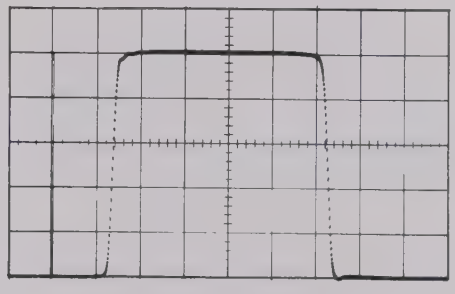
b. Positive Output Pulse Attenuated to 1v (20 db) Using Two External 10 db Attenuators (General Radio #874 10 db Pad) in Series.

Figure 2-3. Attenuation of Positive Output Pulse. Photographed from Hewlett-Packard 185B Sampling Scope. 50 ns/cm, 0.2v/cm.

2.3.3.2 Loading of Idle Output Because of the fast rise times involved, the current amplifiers have a tendency to radiate when unloaded. When only one output is being used, it will be necessary to load the idle output with 50 ohms to prevent ringing on the output pulse due to radiation. The most convenient method of loading the idle output is to turn its attenuator to maximum ccw. An unloaded idle output can cause distortions of greater than 2% on the output being used. See Figure 2-4. Therefore, in order to meet equipment specification with regard to pulse distortion it is mandatory that the user adheres to the instructions given above.



a. Positive Output Pulse with Negative Output Open Circuit. Note Ring on Leading Corner.



b. Positive Output Pulse with Negative Attenuation Turned to ccw. Note Relative Lack of Ring.

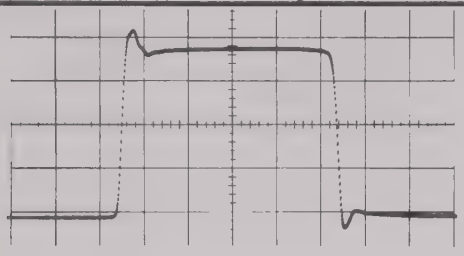
Figure 2-4. Loading of Idle Output. Photographed from Hewlett-Packard, Model 185B Sampling Oscilloscope 50 nsec/cm, 2v/cm.

2.3.4 Loading Considerations

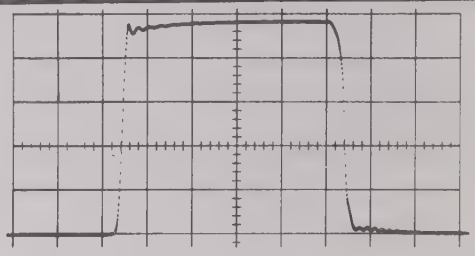
One of the major advantages of the Model 109 over competitive pulse generators is its clean waveforms. In order to preserve this degree of pulse fidelity, it is imperative that due consideration be given to loading. The generation of a clean waveform with rise times of 5 ns requires state of the art circuit design and packaging technique. As such, it is necessary to restrict the type of loading which can be imposed upon the output stages. Because of the wide usage of 50 ohm cables and accessories in industry, the Model 109 was designed for operation with a 50 ohm load.

OPERATING INSTRUCTIONS

The output section of the Model 109 consists of a positive and a negative current amplifier each supplying 200 ma. The operating point of each amplifier is biased near saturation when supplying 200 ma into a 50 ohm load. The load impedance must not vary more than ±5% from 50 ohms if the specified overshoot and undershoot specifications are to be met. Load impedances over 50 ohms cause saturation of current amplifiers and hence, introduces storage time effects; on the other hand, load impedances less than 50 ohms increase the collector voltage of the transistors in the current amplifiers which causes overshoot and ringing. See Figure 2-5. If the outputs are open circuited, the current amplifiers will be in deep saturation and the resultant waveform will be indistinguishable as pulses.

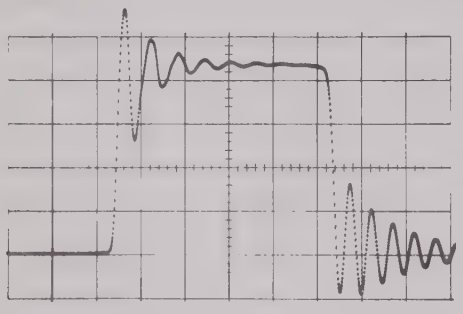


a. Full Amplitude Positive Pulse Loaded into 40 Ohms. Note Overshoot and Undershoot.

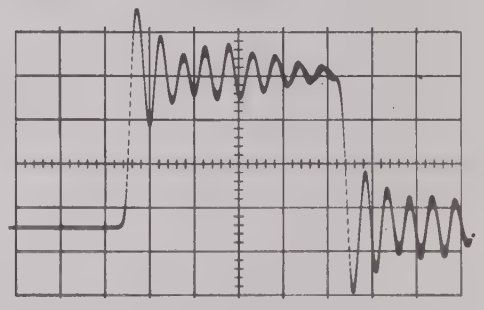


b. Full Amplitude Positive Pulse Loaded into 60 Ohms. Note Ring and Top Slope.

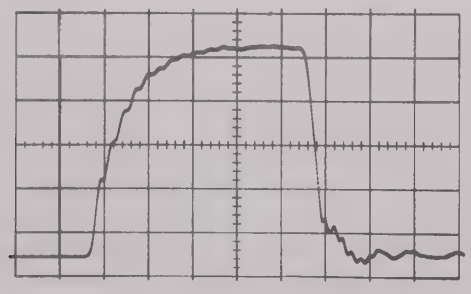
Figure 2-5. Loading Considerations. Photographed From Hewlett-Packard Model 185B Sampling Oscilloscope. 50 nsec/cm 2v/cm.



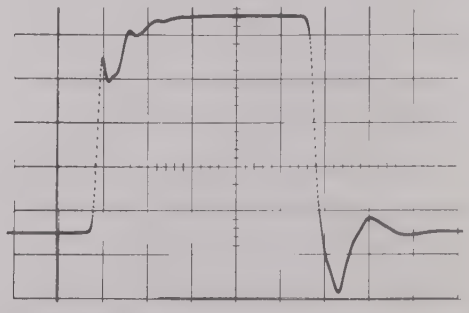
a. Positive Pulse at End of 4-ft RG58A/U Cable Terminated in 50 Ohms at the Generator.



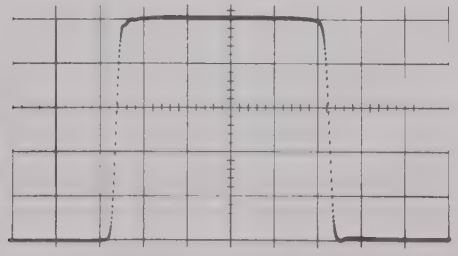
b. Positive Pulse at End of 4-ft. Clip Leads. Terminated into 50 Ohms at the Generator.



c. Positive Pulse at End of 4-ft. Clip Leads. Terminated into 50 Ohms at Scope.



d. Positive Pulse at End of 6-ft. RG63/U (100) Cable Terminated into 50 Ohms at Set Scope.



e. Positive Pulse Through 4-ft. RG58A/U Cable Terminated. in 50 Ohms Scope (Good Technique)

Figure 2-6. Cabling Effects. Photographed from Hewlett-Packard Model 185 Oscilloscope 50 nsec/cm. (e) is 0.5 μsec/cm.

2.3.5 Cabling Considerations

In most cases the Model 109 will be used to drive loads which are physically separated from it by several feet. In this case, it will be necessary to convey the signal by means of a 50 ohm transmission line. Preservation of low distortion waveforms is largely contingent upon the method of cabling and in proper termination of the transmission line. Clean waveforms are maintained by connecting the generator to its load with 50 ohm coaxial cable, and terminating the cable AT THE LOAD into 50 ohms. This is also true of the sync connection to the scope. Figure 2-6 illustrates the effects of poor cabling. Figure 2-7 illustrates proper cabling.

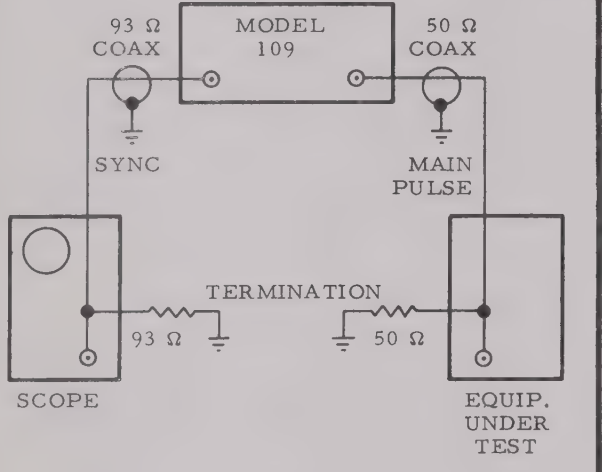


Figure 2-7. Proper Cabling Connection.

2.3.6 Non-Linear Loads

In many cases, the unit will be used to drive non-linear loads such as transistors and diodes. This type of loading generally exhibits high impedance in one direction and low impedance in the other direction Care must be taken to insure uniform loading of the unit in both directions to obtain clean waveforms Figure 2-8 illustrates some of the methods whereby the unit could be terminated when driving into the base of a transistor. The same techniques apply when driving diodes since the base of the transistor resembles a diode.

The external connections shown in Figure 2-8 are suggested for driving into transistor stages. In these examples the "speed up" capacitor will slow down the rise and fall times of the main output pulse. Ringing may occur if the transistor load improperly terminates the generator. It is advisable not to adjust the rise and fall time of the output any faster than is required, since load mismatch is more pronounced at this higher rise/fall frequency. The optional Model 2401 integrator can be used to slow the rise and fall time.

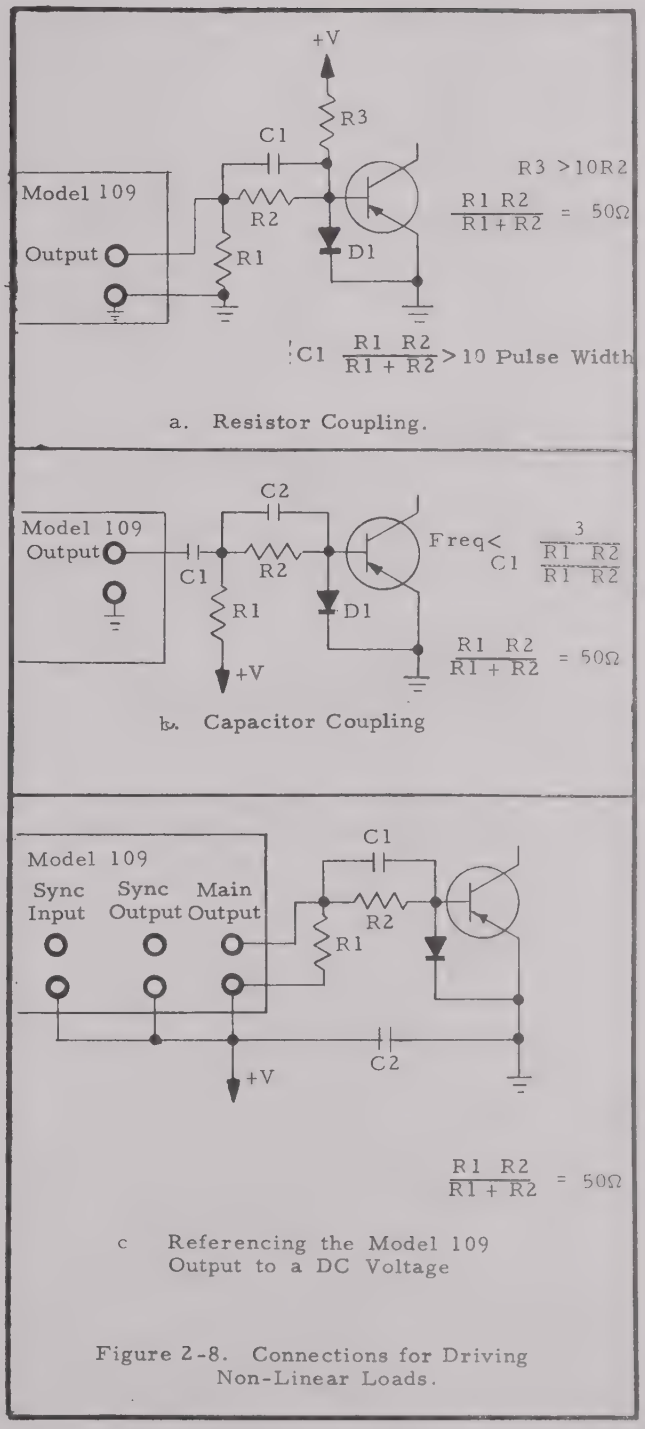


Figure 2-8. Connections for Driving Non-Linear Loads.

These examples illustrate methods of referencing the output pulse so that the transistor will be back biased in the quiescent state.

2.3.7.1 Decoupling Output for Non-Linear Loads When minimal pulse distortion is required and the load is non-linear, it might be necessary to decouple the Model 109 from the load by means of an emitter

follower. The transistor used for the emitter follower must have the following requirements:

a. It must have the frequency response necessary to give the rise and fall times required.

b. Its input capacitance must be low in order to minimize pulse distortion.

c. It must have sufficient gain to supply the current required by the load.

d. It must have sufficient power and voltage required by the load.

The positive output should be decoupled by means of NPN transistors and the negative output should be decoupled by means of PNP transistors. The receiving end of the cable should be terminated directly into a 50 ohm resistor and the input of the emitter follower should be connected to the cable by means of a 22 ohm resistor. See Figure 2-9. The resistor is used as a parasitic suppressor and is absolutely necessary in order to minimize pulse distortion at fast rise and fall times. Of course, the operating voltages and the necessary resistors of the emitter follower are determined by the magnitudes of the voltage and current required by the load.

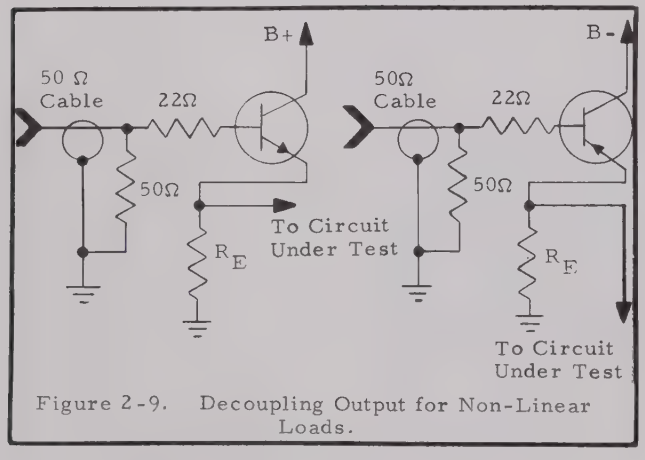
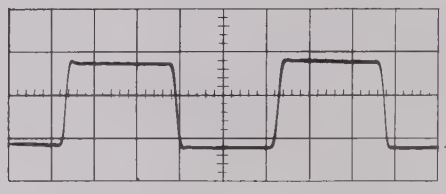


Figure 2-9. Decoupling Output for Non-Linear Loads.

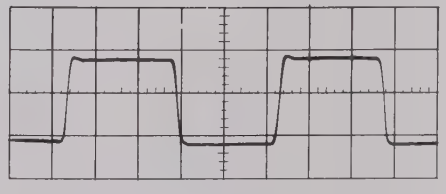
2.3.8 Mixing Several Outputs

The outputs on the Model 109 may be mixed with other outputs if the common load is 50 ohms and if the amplitudes involved are less than 10v. If the outputs of two Model 109's are mixed, the resulting amplitudes will be one-half their unmixed value unless the attenuators of both units are in the maximum cw position. The reason for this is that the output impedance of the attenuator is 50 ohms and, therefore, the resulting load in two Model 109's in parallel, working into a common 50 ohm load, is 25 ohm.

Mixing the outputs in general will degrade the rise time and cause pulse distortion. This condition is usually caused by the output impedance of the units in parallel having reactive components The transition time and the pulse distortion of the Model 109 are given only for a resistive load. Any reactive loading on the output terminal will increase the pulse distortion and the rise and fall times. Best results will be obtained when the Datapulse 2302 mixing network is used to tie the output together. See Figure 2-10 for comparison of results.



a. Result of the Positive Outputs of Two Model 109's Loaded into a Common 50 Ohm Load.



b. Result of the Positive Outputs of Two Model 109's Loaded into a Common 50 Ohm Load Through DP2302 Mixer Unit.

Figure 2-10. Mixed Outputs of Two Model 109's. Taken from Tektronix Type 661 50 ns/cm, 2v/cm

2.4 SPECIAL APPLICATIONS

2.4.1 Multiple Pulse or Pulse Train Operation Using Several Model 109's.

Magnetic device testing, beacon development, and digital or other pulse code simulation often require multiple pulse or pulse train signals. Multiple Datapulse 109 Pulse Generators, when properly connected, will satisfy a broad range of requirements of this type.

Mixing the outputs of several 109's, instead of purchasing a special purpose multipulse generator, offers many advantages. First, pulse parameters may be controlled individually; second, all pulses are selectable in polarity -- a feature not always available

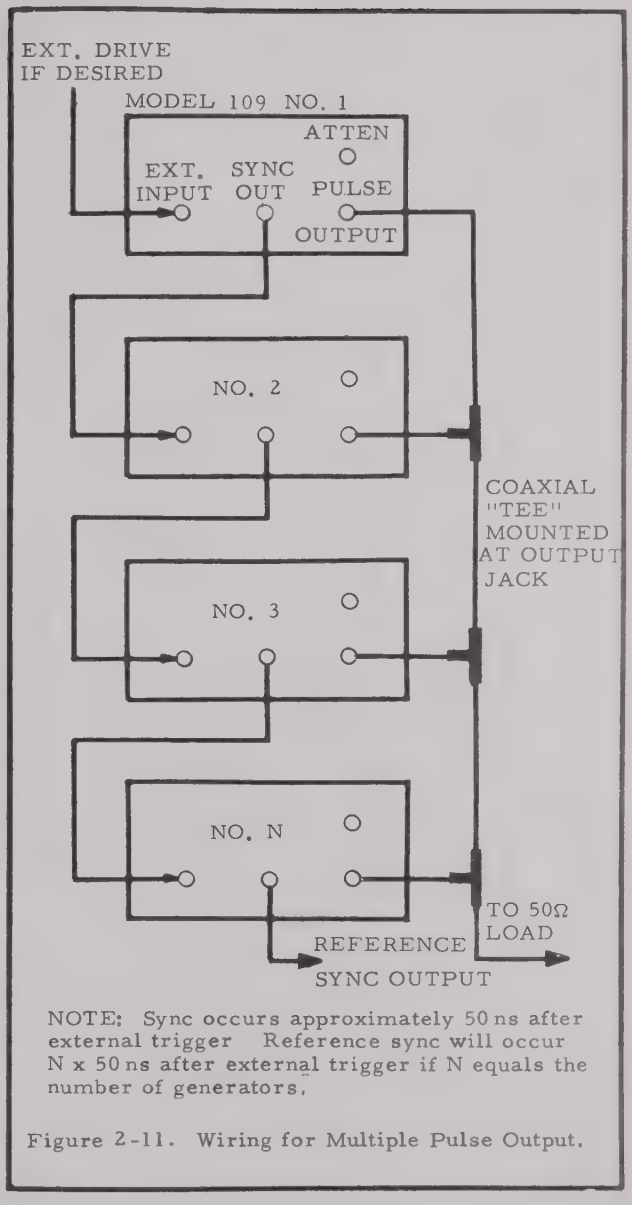
on multipulse generators; third, such an arrangement is more versatile since the individual units may be broken down for use on other projects; and fourth, the combination of simple, proven, easily operated 109's is more dependable than complex special gear.

The 109's may be driven in parallel from an external source, if sync with outside phenomena is desired, or driven in tandem (See Figure 2-11) using the sync output of one generator to externally drive the next. The first generator may be driven from an external source in the tandem arrangement also. Because of the fast rise character of the pulses and narrow widths available, pulse repetition rates approaching 100 mc may be synthesized.

The termination of interconnecting cables has an important effect on output waveform in this arrangement. Improper termination causes reflections which deteriorate wave shape and increase the rise time. However, good waveform fidelity can be obtained by inserting some measure of attenuation (the amount varying with the number of generators) at the generator end with the internal attenuator. The 50 ohm output impedance of the attenuator tends to terminate the interconnecting cables. The greatly decreased waveform distortion more than offsets the slight loss of amplitude sustained.

2.4.2 Positive Sync Output

Some applications require negative polarity sync pulses which are not normally available in the Model 109. Datapulse Model 2101 trigger pulse inverting transformer, available as an accessory, was designed to permit inversions of the negative sync pulse output.



NOTE: Sync occurs approximately 50 ns after external trigger Reference sync will occur N x 50 ns after external trigger if N equals the number of generators.

Figure 2-11. Wiring for Multiple Pulse Output.

SECTION III
THEORY OF OPERATION

3.1 BLOCK DIAGRAM DESCRIPTION

A clock pulse (W1) with a repetition rate which is variable from 4 cps to 40 mc is generated by the internal oscillator. Either this signal or an external trigger input is applied to the Schmitt trigger circuit to provide a standardized trigger (W2). W2 is delayed 50 ns and becomes the negative sync pulse output which is used as a "zero" time reference for the pulse delay circuit. W2 is also applied to the Gating Amplifier which in the absence of an external gating signal, generates the system clock (W3). The clock drives the delay one shot multivibrator to produce a delay gate (W4). The lagging edge of W4 is differentiated by the Pick Off Amplifier which provides the delayed trigger (W5) for triggering the Width One Shot Multivibrator. When the Pulse Mode Switch is in the double pulse position, the system clock (W3) is also fed to the Mixing Amplifier together with the delay one shot pick off signal (W5) to trigger the Width One Shot. In this mode, the Width One Shot is triggered twice for each cycle. The width gate (W7) produced by the pulse Width One Shot is applied to the Negative and Positive Output Amplifier by the Buffer Amplifier. See Figure 3-1 for block diagram.

The Positive Output Amplifier converts W8 to a positive going pulse (W9) of 10 volts into 50 ohms. W9 is coupled to the output BNC jack by means of a 50 ohm variable attenuator. The polarity of W8 is inverted by the Inverter Amplifier before it is fed to the Negative Output Amplifier. The output of the Negative Output Amplifier (W11) is a negative pulse of 10 volts into 50 ohms. W11 is coupled to the output BNC jack by a variable 50 ohm attenuator. Both the positive and negative attenuators are capable of zero db to over 20 db's of attenuation.

3.2 CIRCUIT DESCRIPTION

3.2.1 Internal Oscillator

The Internal Oscillator is an emitter coupled circuit which has the advantages of self-starting, stability, and high frequency operation. The basic circuit is shown in Figure 3-2. The actual oscillator is composed of Q2 and Q5. The function of Q1 is to provide the base voltage ($-V_2$) for Q2 and the clamp voltage ($-V_3$) for CR2. Q6 serves to decouple the load from the output.

Assume that Q2 has just turned on. The negative signal at the collector of Q2 is fed back to the emitter of Q2 through the emitter follower Q5 and the timing capacitor C_T. This feedback is positive and it tends to keep Q2 in the ON state. During this phase the emitter current of Q2 flows through C_T and Q5 to -5 volts. This current charges capacitor C_T. The charge in C_T increases which causes the current through it to decrease. Eventually, the charge accumulated in C_T is sufficient to cause Q2 to be cut off. The collector of Q2 then rises back to ground. C_T then discharges through R14 and R_T. When C_T discharges to value such that the emitter voltage of Q2 is more negative than its base voltage, Q2 turns on and the cycle is repeated again.

The duration of the ON period is determined by the value of R10 and C_T. The duration of the OFF period is determined by the value of C_T, R_T, and R14. The repetition rate is the reciprocal of the sum of the two periods. The repetition rate may be altered either by changing the value of R_T or C_T. In the Model 109, R_T is the Vernier and C_T is the Range.

3.2.2 Schmitt Trigger

The Schmitt Trigger is used to standardize waveforms either from the internal oscillator or from the external triggering source. Because of regeneration during switching, the output of the Schmitt Trigger has fast rise and fall times which are relatively independent of the input waveshapes. The simplified circuit is shown in Figure 3-3.

In the quiescent state, Q7 is ON and Q8 is OFF. A negative signal of 1.5 volts at either input A or input B will cause Q7 to cut off. The positive going signal at the collector of Q7 is coupled to the base of Q8 and turns it on. This positive signal is fed back to the emitter of Q7 and turns it off harder. The output of Q8 is a negative going signal of 3v with a rise time of less than 10 nanosec.

3.2.3 One Shot Multivibrator

The One Shot Multivibrator is used for delaying and providing the duration of the main output pulses. The circuit used in the Model 109 is an emitter coupled univibrator and the simplified circuitry is shown in Figure 3-4. Both the Delay and Width Univibrators are similar and the description that follows applies to both.

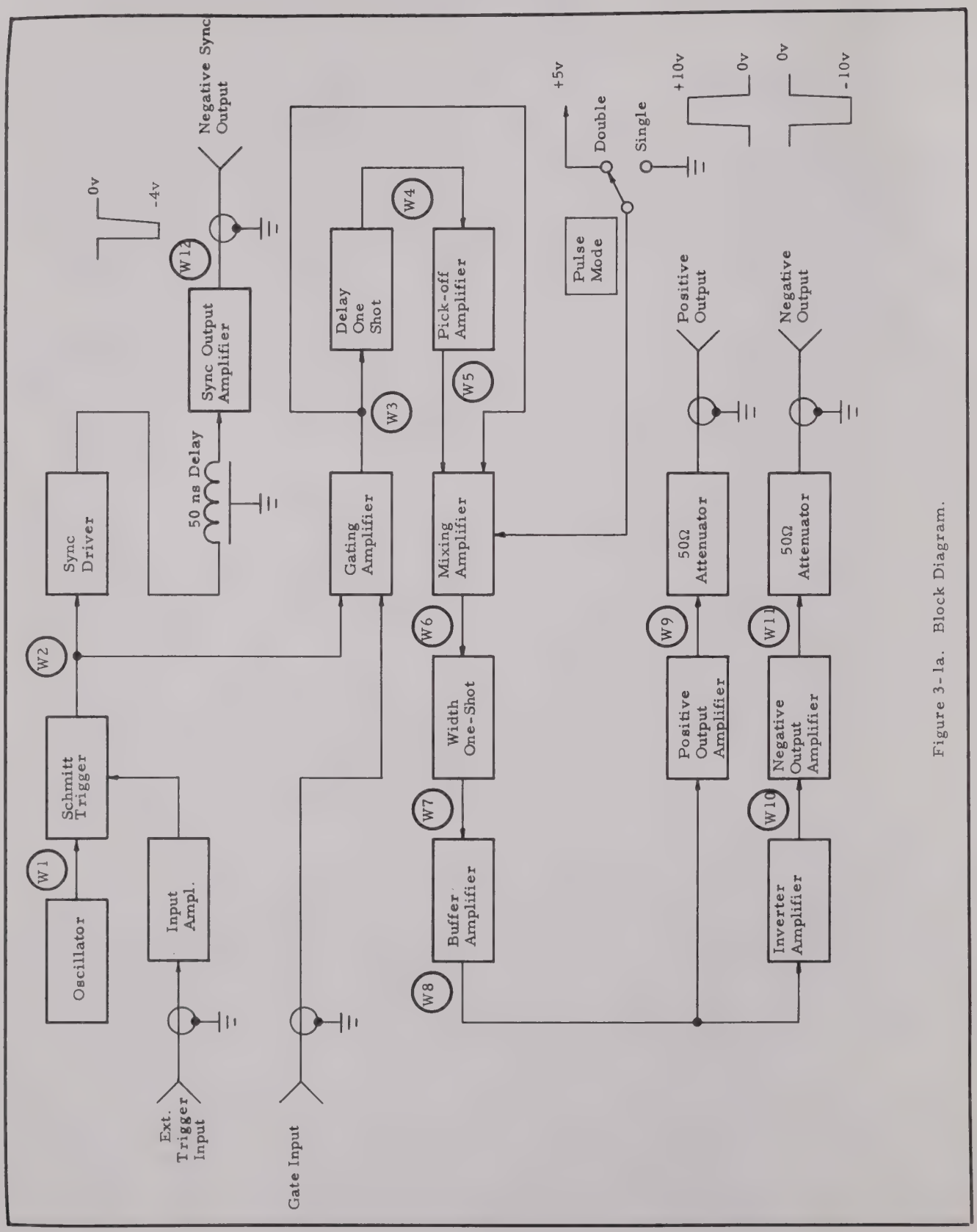


Figure 3-1a. Block Diagram.

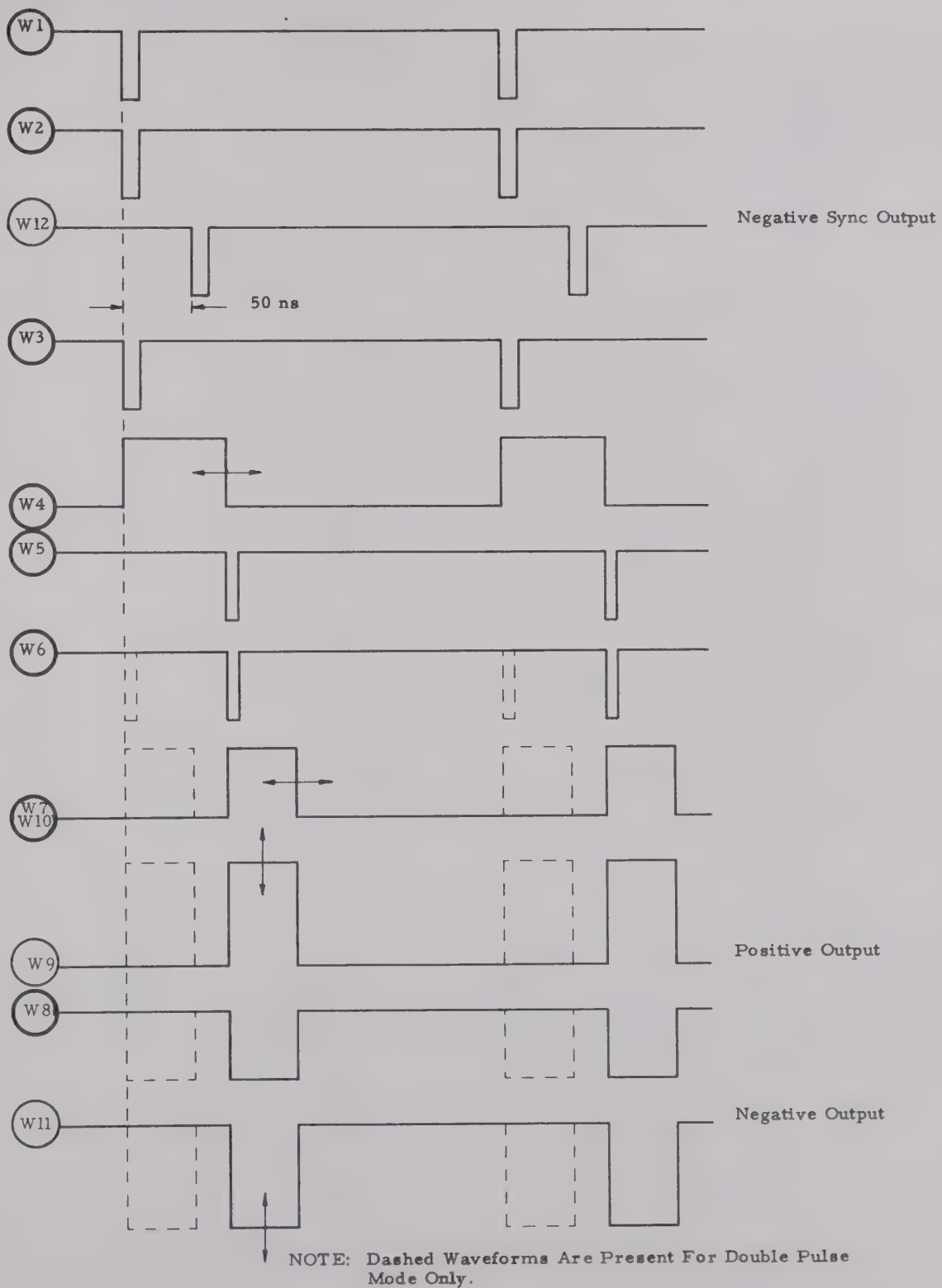


Figure 3-1b. Timing Diagram.

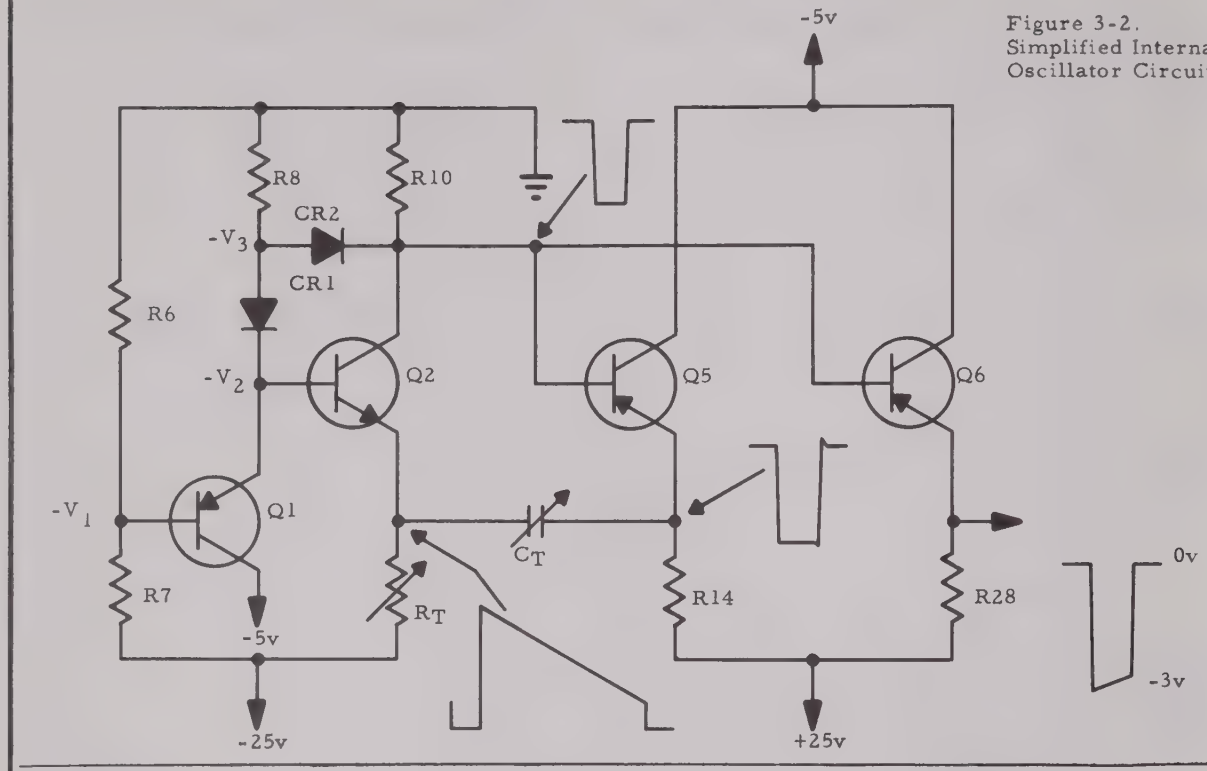


Figure 3-2.
Simplified Internal
Oscillator Circuit.

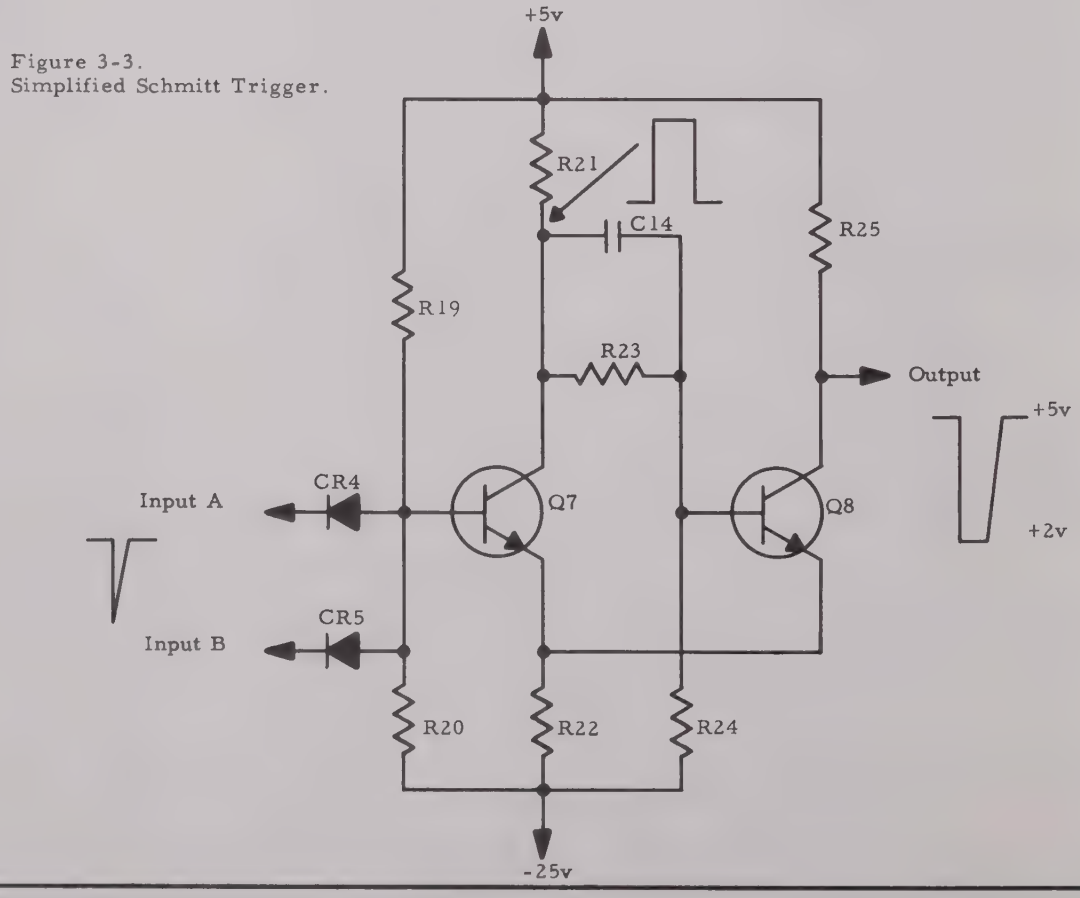


Figure 3-3.
Simplified Schmitt Trigger.

Quiescently, Q26 is ON and Q27 is OFF. This condition is caused by the base of Q26 being positive by the forward voltage drop of CR121 and the base of Q27 being negative by the forward voltage drop of CR124. The collector voltage of Q26 is clamped to $+V_1$ by CR123 and this keeps Q26 out of saturation. Q28 is an emitter follower which provides feedback to Q27. The output signal is taken from the emitter follower, Q29.

Operation of the circuit is initiated by a negative pulse at the input of Q26. This cuts off Q26 and causes its collector voltage to rise to +5v. This positive pulse is fed back to the emitter of Q26 via Q28, C_T, and Q27 and keeps Q26 in the OFF state. C_T is discharged by R_T to -25v and causes the feedback voltage to diminish in amplitude. When the feedback voltage diminishes to a value less than that required to keep Q26 in the OFF state, Q26 turns on again. This terminates the output pulse and the circuit returns back to its quiescent state.

The discharge of C_T occurs in a linear manner because the magnitude of the feedback signal is small compared to -25 volts. Hence, the feedback signal crosses the switching threshold in a linear manner and this results in an output pulse having very low jitter. The duration of the output pulse is a function of both R_T and C_T. In the Model 109, C_T is used as the Range Control and R_T is used as the Vernier.

3.2.4 Pick Off Amplifier

The purpose of the Pick Off Amplifier is to differentiate the output of the Delay Univibrator. The trailing edge is inverted and becomes the input for the Mixing Amplifier. The simplified circuit is shown in Figure 3-5.

Q20 is an emitter follower which buffers the output of the Delay Univibrator. The output of Q20 is differentiated by the transmission line, DL80. The negative lagging edge is applied to the base of Q21 through CR85. Q21 is normally on because its base is more positive than its emitter. The negative pulse turns off Q21 and its collector goes positive. The output of Q21 is then applied to the Mixing Amplifier.

3.2.5 Gating Amplifier

The Gating Amplifier is used to generate the system clock and to interrupt it upon the application of an external gating signal. The amplifier is composed of Q14, Q15, and Q16 as shown in Figure 3-7. Q14 and Q15 form a differential amplifier and Q16 is an inverter. In the quiescent state, Q14 is ON and Q15 is OFF be cause the base of Q14 is more positive than the base of Q15. The output of the Schmitt Trigger drives the base of Q14 which in the absence of an external gating signal, turns Q14 off. The positive pulse at the collector of Q14 is inverted by Q16. The system clock is taken from the collector of Q16.

To inhibit the clock output, a positive voltage of more than 3.5 volts must be applied to the base of Q15. This turns on Q15 and turns off Q14. By keeping Q14 in the OFF state, no output will result when negative pulses are applied to its base. Diodes CR63, CR64, CR65 and CR66 are used to clamp the base of Q15 both positively and negatively to prevent damaging Q15 due to excessive voltages at the gate input.

3.2.6 Mixing Amplifier

The purpose of the Mixing Amplifier is to generate the trigger pulse for the Width One Shot Multivibrator. The basic circuit is shown in Figure 3-6. Q23 and Q24 is an "Or" gate which provides power gain from the input to the output. Q22 is an inverter which provides an input to Q23 when the Pulse Mode Switch is in the double pulse position. When the Pulse Mode Switch is in the single pulse position, CR113 clamps the collector of Q22 from going above ground.

Q25 is an inverter which accepts the output of the "Or" gate and drives the Width One Shot. In the double pulse mode, Q25 generates two pulses for each cycle of operation; one at clock time and one at delay time. In the Single Pulse Mode, the pulse at clock time is inhibited and only the pulse at delay time is generated.

3.2.7 Input Amplifier

The Input Amplifier is used to generate the driving signals for the Schmitt Trigger. The circuit is composed of Q9 and Q10 as shown in drawing 40000-101. When the Repetition Rate Switch is in the +EXT position, the input driving signal is inverted by Q10 and its output is used to drive the Schmitt Trigger.

When the Repetition Rate Switch is in the -EXT position, the negative input signal is fed to the Schmitt Trigger by the emitter follower, Q9. R32 is a sensitivity control and is used to reject the noise on the external input. S31 is used to control the input impedance of the Input Amplifier and it should always be in the 50 ohm position when the external signal is brought to the input by means of 50 ohm cables. CR31 and CR32 are used to limit the maximum voltages at the base of Q9 and Q10 to prevent them from being damaged due to excessive voltage.

3.2.8 Output Stages

The Output Stages consist of current drivers working into a 50 ohm load. Current output has the advantage of built-in short circuit protection in that it is relatively insensitive to load impedance. This means that the short circuit output current is the same as the normal output current. Hence, the maximum dissipation that the output transistors must handle is fixed and known in advance. Both the positive and negative output drivers use the grounded base configuration. The advantages of this configuration are:

a. Higher breakdown voltage.

b. Faster rise time.

c. Outputs may be mixed with other outputs.

d. Cleaner waveshapes.

e. Less susceptibility to damage.

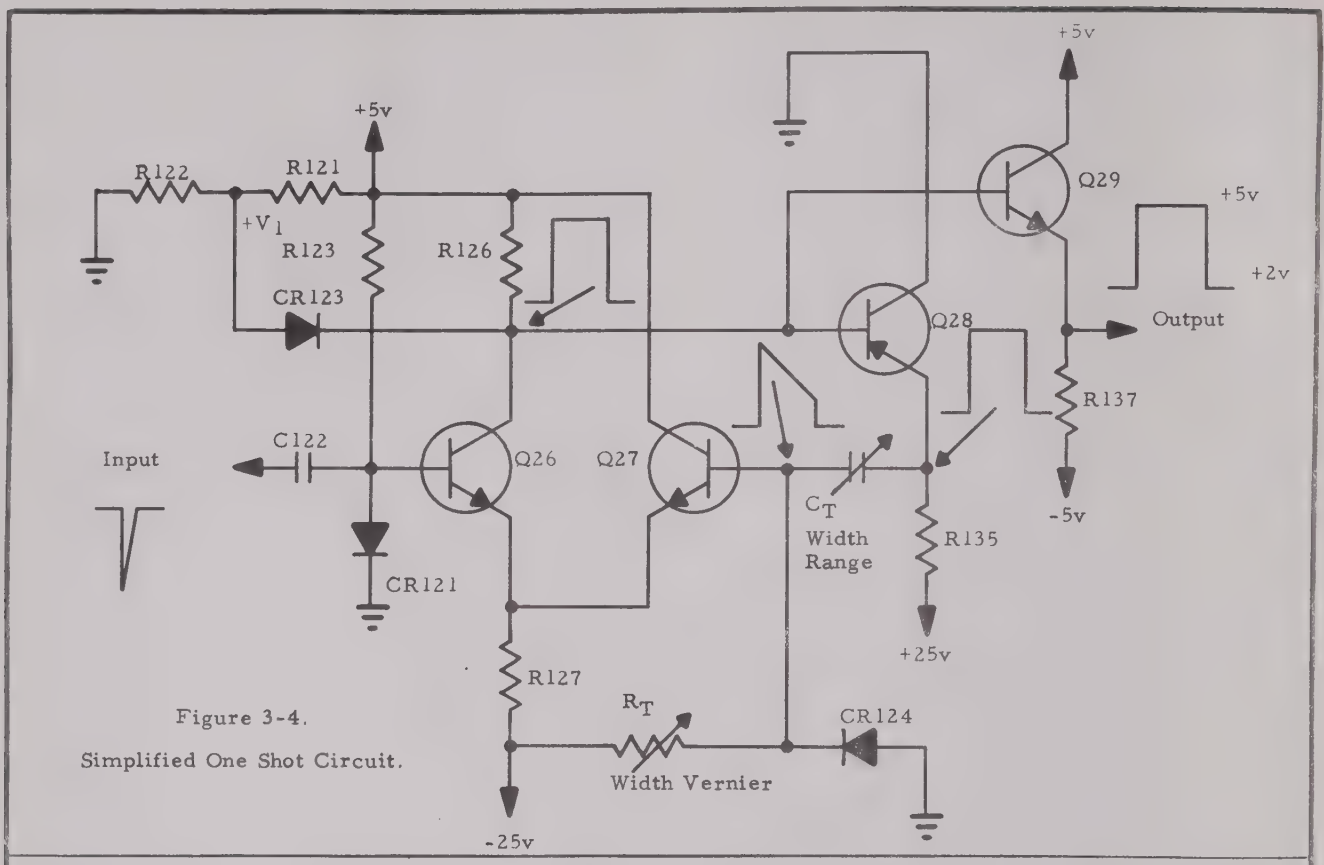


Figure 3-4.
Simplified One Shot Circuit.

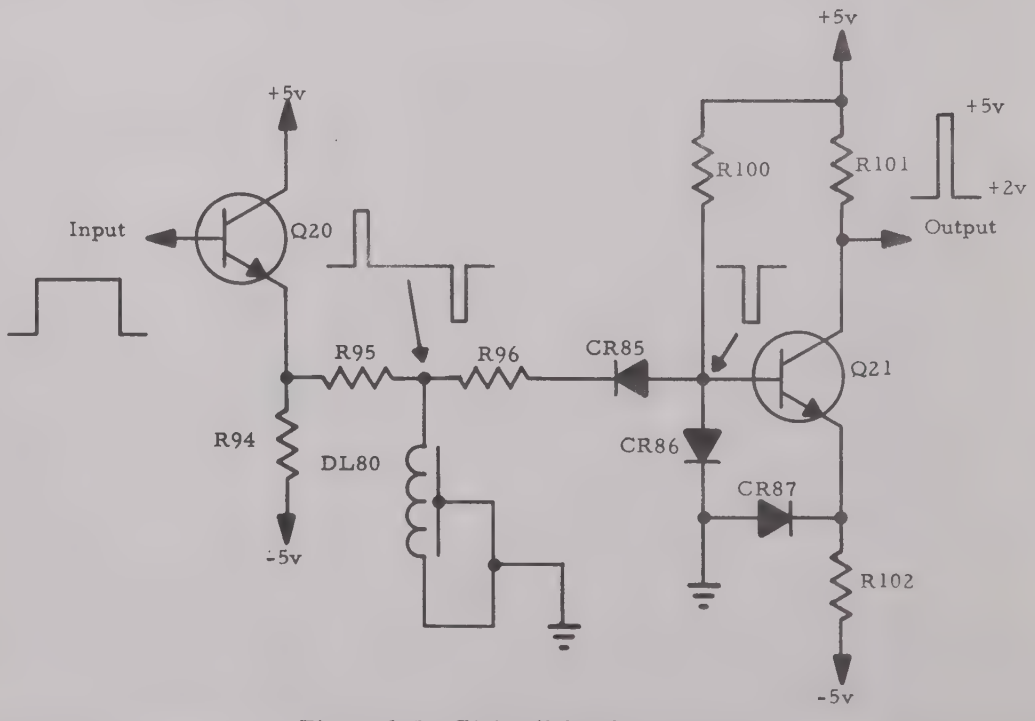


Figure 3-5. Pick Off Amplifier.

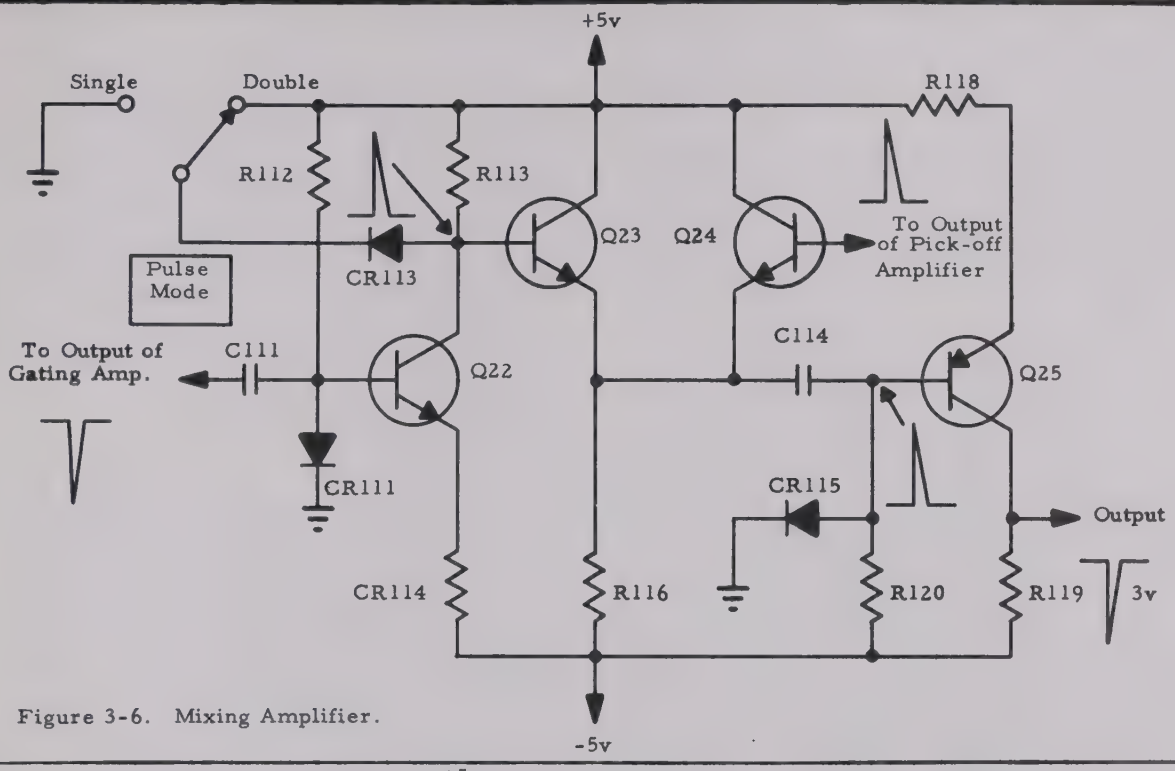


Figure 3-6. Mixing Amplifier.

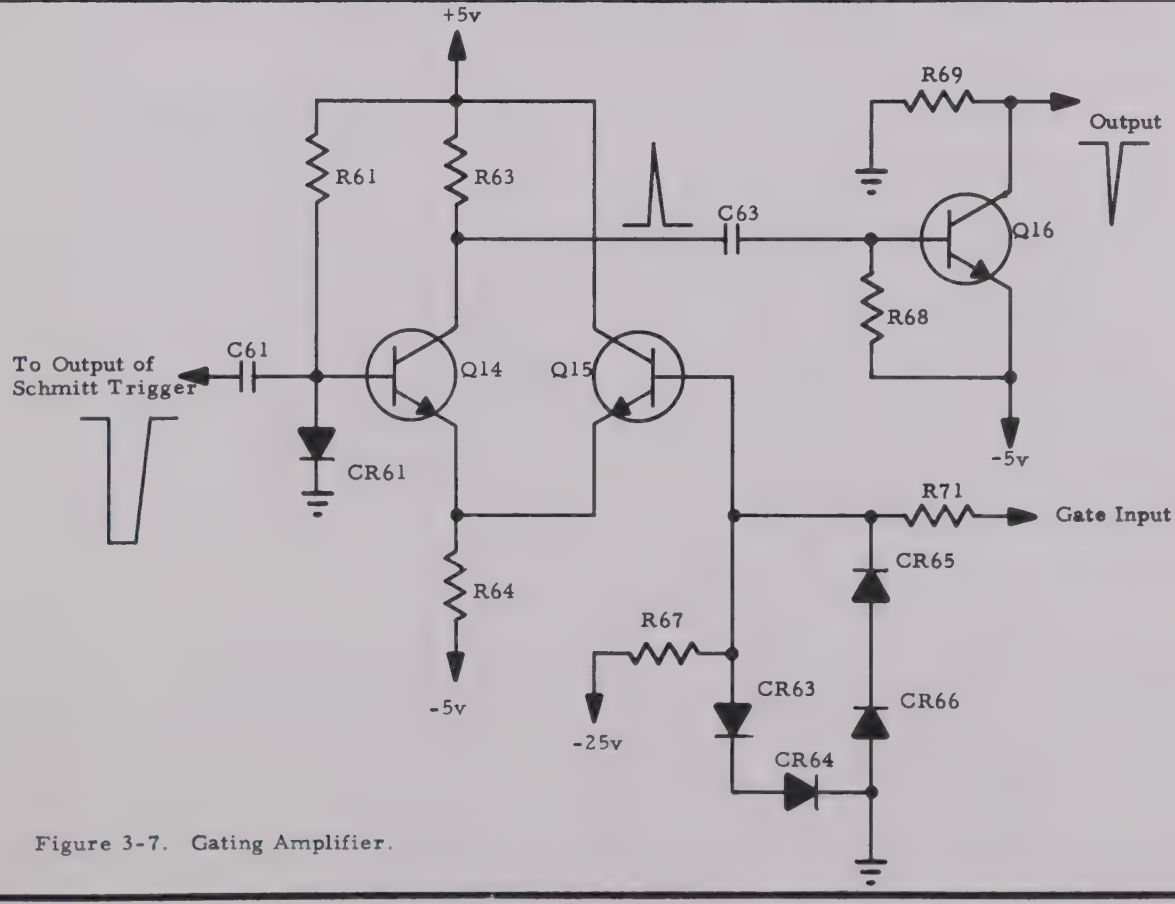


Figure 3-7. Gating Amplifier.

As a result of the configuration, the output amplifiers of the Model 109 are capable of sustained operation into a short circuit with no ill effects. In addition, the output of the Model 109 may be mixed with other outputs as long as the voltages being mixed are less than ±10 volts.

3.2.8.1 Positive Output Amplifier: The Positive Output Amplifier is shown in drawing No. 40000-102 and consists of three grounded base stages in parallel. The output drivers are Q306, Q307 and Q308. Each output transistor is driven by an inverter, Q303 through Q305. The inverters are buffered by two emitter followers, Q301 and Q302.

The circuit is started by the application of a negative 3 volt pulse to the base of Q301. The output of Q301 is ac coupled to the base of Q302 where the reference baseline is changed from +5v to +10v. The negative output of Q302 is applied to the bases of Q303, Q304, and Q305 and causes them to turn off. The current that was normally flowing through Q303, Q304, and Q305 is diverted to the output transistors Q306, Q307, and Q308. The total required output current is 200 ma and each transistor supplies 66.6 ma. Notice that the output current is dependent only on the values of R309, R310, R311, and the emitter voltage of Q309. Therefore, the output current is fixed and independent of the load impedance. Q309, Q310, and Q311 are a variable power supply which provides base voltage for the output transistors and acts as a current sink for the inverter transistors, Q303 to Q305. In the event that the output is working into an open circuit, CR309, CR310 and CR311 clamp the output from going above +11 volts. The output is coupled to a variable, constant impedance type, 50 ohm attenuator whose output is brought to the front panel BNC jack. For correct operation, the output must always be terminated into a good 50 ohm load.

3.2.8.2 Negative Output Amplifier: The Negative Output Amplifier is shown in drawing No. 40000-102. It consists of three grounded base stages in parallel (Q321, Q322, and Q323) each being driven by an emitter follower (Q318, Q319, and Q320). The bases of Q318 through Q320 are tied together and they are driven by the output of an emitter follower, Q314. Q314 is driven by emitter follower, Q313, which in turn, is driven by inverter, Q312.

A positive 3 volt pulse is fed to the base of Q312 to start circuit operation. The negative output of Q312 is decoupled by emitter follower, Q313. The output of Q313 is ac coupled to the base of emitter follower Q314. The negative output of Q314 cuts off emitter followers Q318, Q319, and Q320. The current normally flowing in these emitter followers now flows through the output transistors. The total output current is 200 ma and each output transistor supplies 66.7 ma. As with the case of the Positive Output Amplifier, the current in the Negative Output Amplifier is also independent of the load impedance. The current flowing through each output transistor is dependent only upon its base voltage and its emitter resistance. The collectors of each output transistor are clamped to -11 volts to limit the output amplitude during open circuit conditions. The amplitude of the output voltage is controlled by a 50 ohm variable attenuator, continuously variable from 0 to over 20 dbs.

3.2.9 Power Supply

The Power Supply consists of two positive regulators and two negative regulators as shown in drawing 40000-100. The ac line input is stepped down to 29 v rms to each secondary of T501. The secondary voltages are rectified by two bridge rectifiers, CR510 to CR513 for the positive voltage and CR531 to CR534 for the negative voltage. The output of the positive bridge rectifier is filtered by R510 and C510. The filtered output is regulated to +25 volts by a series type regulator composed of Q501, Q502, and Q503. Q501 is a reference amplifier which compares the output voltage against the output of the reference zener diode CR514. The error signal is fed to the base of Q503 by means of emitter follower Q502. The polarity of this signal is such that it always opposes the change in the output voltage. The value of the output voltage is determined by the setting of R517. +25 volts is divided down by R519, R520, and R521 to generate +5 volts. Q505 and Q506 are used to supply +5 volts to the load. Both the +25 volt and the +5 volt regulators are protected against short circuit loads.

The output of the negative bridge rectifier is filtered by R531 and C531. The filtered output is regulated at -25v by a series regulator composed of Q508, Q509, and Q510. The operation of this regulator is the same as in the +25v regulator. -5 volts is generated by R540, R541, and R542. Q511 and Q512 supply -5 volts to the load. As with the +25 volt and +5 volt regulators, the negative regulators are also protected against short circuit conditions.

SECTION IV

MAINTENANCE INSTRUCTIONS

4.1 PREVENTIVE MAINTENANCE

4.1.1 Preventive Inspection and Service

Inspection and service of a preventive nature will result in optimum performance and longer life of this instrument. Dust covers should be removed at regularly scheduled intervals to permit inspection for dust, tarnish, corrosion, loose nuts and bolts (especially those serving as electrical conductors), loose cables and fuses, charred insulation, scorched resistors and broken wiring. Discoloration of the printed circuit board, due to heat, does not affect the board's electrical properties and may be disregarded in most cases.

4.1.2 Minor Repairs

The operator should be thoroughly acquainted with the instrument's circuit theory and component location before attempting repair. In all cases, setting and adjustment of controls should be checked in order to verify that difficulties encountered are actually caused by malfunction and not by operation outside of specifications. Check transistors in suspected circuits prior to conducting extensive test on other components. A check of the important waveforms as shown on schematics will be of great assistance.

4.1.3 Recalibration

This instrument was designed to provide maximum reliability and stability. To insure that accuracy remains within stated limits, we suggest that calibration be checked after every 200 hours of operation. See Section 4.5 for calibration check. If the unit is used intermittently, calibration should be checked every three months. Complete instructions for calibration are given in this manual.

4.2 PARTS REMOVAL AND REPLACEMENT

4.2.1 General

This instrument is sturdily built. Components are accessible and removal is so simple that explanations are unnecessary. However, some parts are more easily removed if a definite procedure is followed. Replacement of some parts will also require partial recalibration. Refer to Section 4.4 of this manual for calibration instructions.

4.2.2 Removal of Dust Covers

The dust covers are held in place by small screw-head quick disconnect fasteners. To remove, turn all fasteners a quarter-turn counterclockwise with a screwdriver and lift the cover up and off.

4.2.3 Replacement of Power Transistors

The power transistors which are mounted on the rear panel must have a thin film of silicon grease (such as Dow-Corning DC-4) applied to their common contact surfaces.

4.2.4 Soldering Considerations

Although printed wiring is quite vulnerable to heat excesses, a great deal of resoldering can be done on a single joint if care is taken. A 35-watt wedge tip or pointed tip iron and 60-40 rosin core solder are quite effective. Where both sides of the board are accessible apply the tip of the iron (on the side opposite the component) directly to the solder fillet and pull gently on the pigtail with pliers from the opposite side. Where both sides of the circuit board are not accessible, the component lead will be fed through the board through an eyelet. Apply the iron tip to the eyelet and pull the pigtail out with pliers. To insert a new component, clean out the hole with a sharp object (it may be necessary to apply more heat) and insert the new component, soldering in the old place.

4.3 TROUBLESHOOTING PROCEDURE

Before any troubleshooting is attempted, the front panel controls should be checked for proper setting. You may wish to refer to paragraph 2.3, operating considerations, which details many of the limitations of the instrument and describes the performance to be expected. After you have ascertained that a trouble does exist, you may continue according to the procedures outlined in this section.

Many apparent malfunctions are due to improper calibration of one or more of the circuits, and often a transistor is replaced that requires recalibration. If you suspect that a circuit is miscalibrated, section 4.4 provides a detailed calibration procedure.

Whenever trouble occurs check the power supply voltages. This test may be done by following paragraph 4.4.3 of the calibration procedure. It may be assumed that the power supplies are functioning properly if the output and ripple voltages are correct.

When malfunction can be attributed to a particular circuit, perform a complete visual inspection in that area. See Figure 4-1 for the location of circuits. Frequently visual inspection reveals the effects of the trouble (such as burned resistors) rather than the cause. However, these effects may give clues as to the actual cause. Care should be taken to find the real cause.

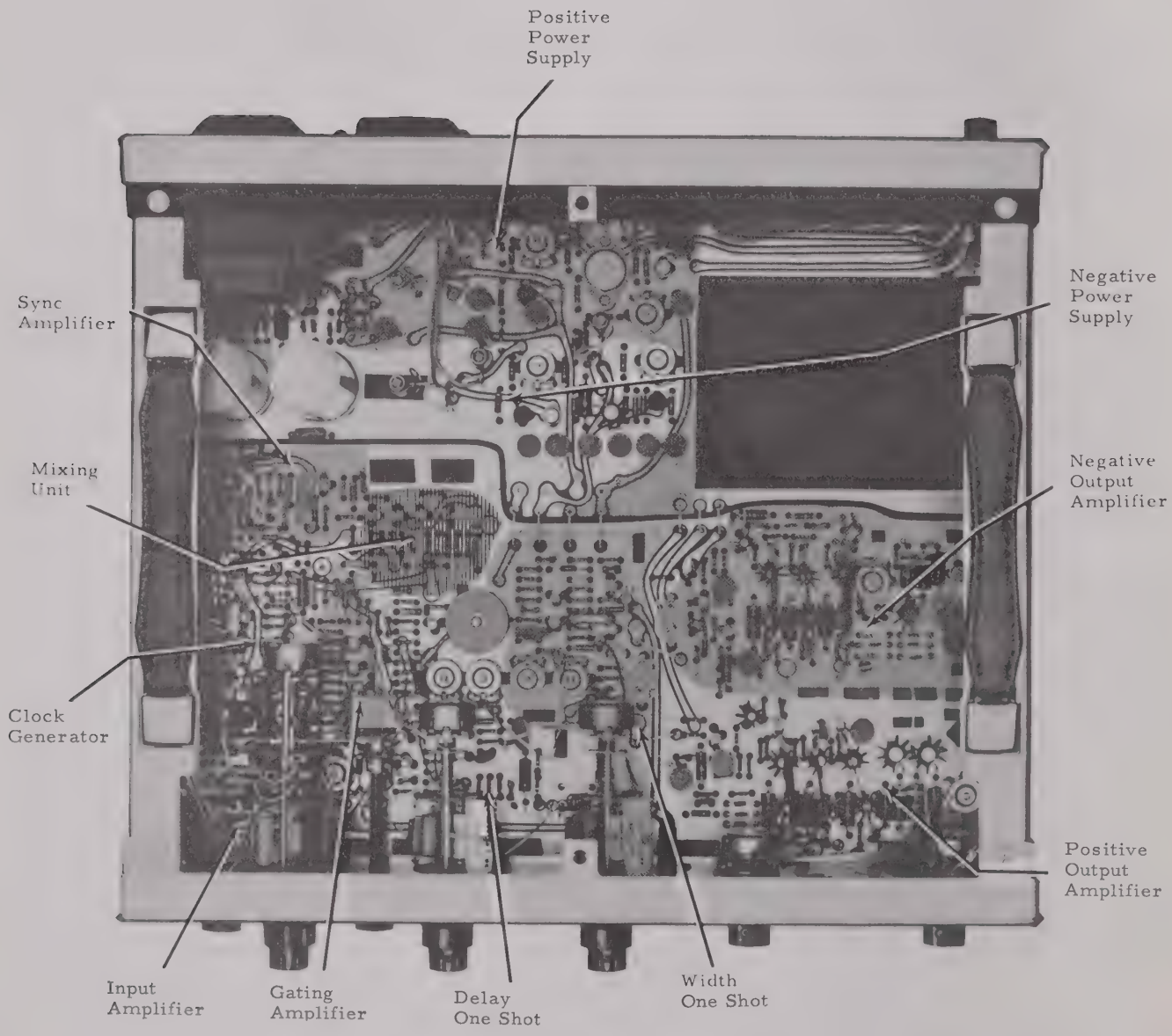


Figure 4-1. Circuit Locations.

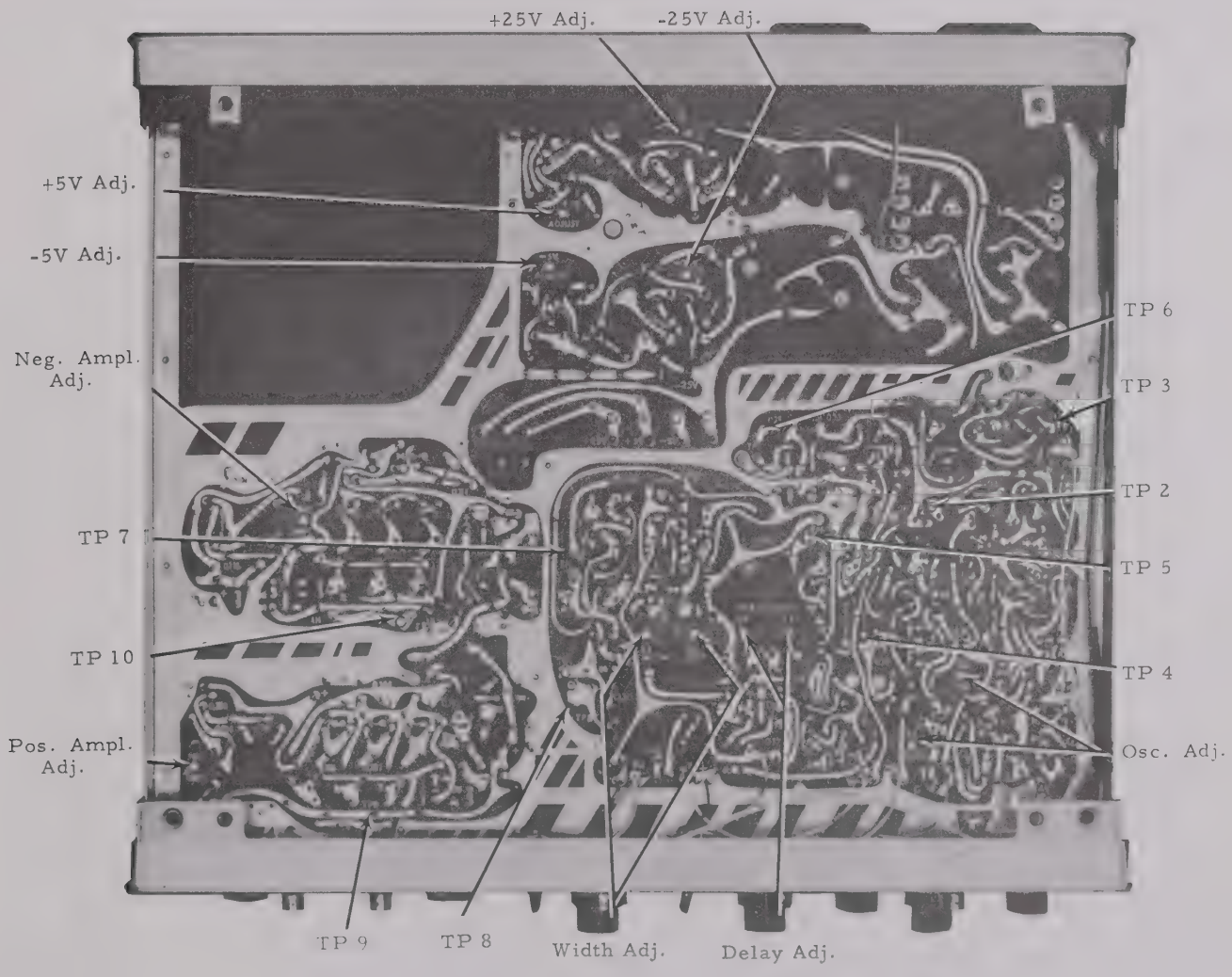


Figure 4-2. Adjustments and Test Point Locations.

4.3.1 Troubleshooting the Power Supplies

Almost all power supply failure may be typified by collector to emitter shorts (transistors) and anode to cathode shorts (rectifiers and zener diodes). These conditions are easily detected "in circuit" with an ohmmeter.

4.3.2 Troubleshooting the Pulse Circuits

Once it has been ascertained that the power supplies are functioning correctly, the most straight forward method of tracking down a trouble is to begin at (W1) in the clock generator and proceed through the instrument comparing waveforms to those shown on the schematics. When the proper waveform is distorted or missing entirely then a comparison of voltage and resistance readings to those listed in Table 4-1 will generally narrow the trouble down to one of a very few components. Because of the "straight through" nature of the instrument circuitry, most troubles will manifest themselves as complete absence of output pulses or invariability of one or more of the pulse parameters. In the later case a good indication is given as to which circuit to suspect.

4.4 CALIBRATION PROCEDURE

4.4.1 General

Remove dust covers and connect instrument and ac voltmeter to auto transformer. Set to 115v ac (230v if so wired) and energize instrument. Allow five minutes warmup before commencing calibration. During this period make sure that the instrument is working properly. If any portion of the instrument fails to calibrate, repair should be effected before attempting to complete calibration.

4.4.2 Equipment Required

a. Rms reading ac voltmeter with 0-150v range (0-300v range if wired for 230v operation).

b. Variable line auto transformer such as Powerstat Series 20.

c. A multimeter with an accuracy of at least 3% and a sensitivity of 20,000 ohms per volt, such as a Triplett 630 or equivalent.

d. A general purpose oscilloscope of at least 30 mc band-pass with either delayed sweep or high sweep magnification. Hewlett-Packard Model 175A or Tektronix Type 543 is suitable.

e. A wide band oscilloscope such as Tektronix Type 661 with 4S1 Plug-in is necessary for fine adjustment of output waveform.

f. 50 ohm load termination (DP#2003).

g. An insulated, low-capacity screw driver.

h. 100Ω, 10w, wire wound resistor.

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TABLE 4-1. VOLTAGES AND RESISTANCES

Unless otherwise noted, measurements were made under the following conditions:

Control Settings:

Rep. Rate: 4 mc, Vernier cw.
Pulse Delay: 0.5 nsec, Vernier ccw.
Pulse Width: 0.5 nsec, Vernier cw.
Amplitude: ±10 v, Vernier cw.

Negative, positive, and sync outputs:

Loaded with 50 ohms.
Input Impedance: 50 ohms.
Mode: Single Cycle.

All measurements were made with respect to ground.

All measurements were made with Triplett Model 630 Multimeter (20,000 ohms per volt). Note: Some meters have different internal wiring on resistance ranges. In such an instance, polarity of resistance readings may be reversed.

Resistance readings in second column indicate positive meter lead connected to ground.

The X10 resistance range was used unless noted. The X1000 resistance range was used for all values given in k ohms. The use of higher ranges may employ voltages injurious to transistors. The voltages and resistances tabulated here are typical values. On some instruments the readings may differ considerably from this tabulation due to manufacturing tolerances and variations in component characteristics. This table should be used in conjunction with careful study of the schematic diagrams and the theory of operation section of this manual.

All voltages are dc.

All voltage measurements were made with 115v ac line voltage.

(FRONT END) MODEL 109

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		Emitter	Base	Collector	Emitter		Base		Collector	
Q1	OSC	-2.8	-3.1	-5.4	450	85	40	750	22	75
Q2		-.65	-2.5	250	4k	450	850	85	250	
Q3		-.30	0	0	2.7k	100	12.5k	350	19k	-
Q4		-.30	.35	-.45	2.7k	90	3.3k	300	6.5k	-
Q5		-.30	-.75	-5.4	42	75	90	450	2.7k	
Q6		-.30	-.65	-5.4	3.3k	90	80	350	-	75
Q7		-.6	-.15	2.15	200	1.2k	800	42	180	140
Q8	Input Amp.	-.6	-2.6	5.2	200	1.2k	500	250	85	180
Q9		-.80	-.15	5.0	120	2.5k	200	1.3k	95	50
Q10	Sync Output Amp.	-.30	-.70	-.45	18	17	43	40	500	90
Q11		5.4	5.2	0	2.8k	18	11	300	0	0
Q12		-.35	.40	2.45	14	300	11k	40	250	200
Q13	Gating Amp.	-5.5	-5.4	-.35	43	80	350	110	600	65
Q14		-.15	.5	2.65	38	500	3.5k	100	250	200
Q15		-.15	-1.25	5.4	38	500	6.5k	200	150	100
Q16	Delay One Shot	-1.35	-1.35	-.40	60	90	350	180	200	250
Q17		-.25	-.10	3.4	130	1.6k	42k	300	37	100
Q18		-.20	-.30	5.4	130	1.6k	110	55	44	3
Q19		3.5	3.4	0	1.5k	20	15	170	0	0
Q20		2.6	3.2	5.4	95	190	95	46	46	3
Q21	Mixing Ckt.	-.45	.25	2.15	36	500	2.2k	12	400	100
Q22		-.15	.55	1.25	37	500	4.2k	40	350	100
Q23		1.45	1.25	5.4	130	500	400	55	45	3
Q24		1.45	2.10	5.4	130	500	400	55	45	3
Q25	Width One Shot	-.35	-.80	-.60						
Q26		-.60	-.05	1.55	150	1.7k	4.2k	350	500	250
Q27		-.60	-.45	5.5	150	1.7k	120	55	45	3
Q28		2.7	1.55	0	1.5k	18	14	300	0	0
Q29		2.70	2.05	5.5	120	800	500	95	45	3
Q30		.15	.35	4.1	18	18	40	120	70	180

* All switches in position shown on schematic with verniers fully clockwise.

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OUTPUT AMPLIFIER MODEL 109

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		E	B	C	EMITTER		BASE		COLLECTOR	
	Positive Output Amp.									
Q301		4.30	4.10	.55	1k	35	50	250	28	25
Q302		10.8	10.8	5.9	500	160	120	13k	80	36
Q303		10.8	10.8	12	90	70	200	170	250	180
Q304		10.8	10.8	12	90	70	200	170	250	170
Q305		10.8	10.8	12	90	70	200	170	250	160
Q306		12	13	3.0	250	160	130	2.4k	46	46
Q307		12	13	3.0	250	160	130	2.4k	46	46
Q308		12	13	3.0	250	170	130	2.4k	46	46
Q309		10.8	10	5.2	90	70	40	1k	-	70
Q310		4.6	5.2	10.8	36	36	-	70	90	70
Q311		4.6	5.2	10.8	36	36	-	70	90	70
	Negative Output Amp.									
Q312		10.8	10	5.2	18	18	40	80	95	180
Q313		4.6	5.2	10.8	1k	35	50	450	28	26
Q314		4.6	5.2	10.8	350	200	3.6k	6k	500	10k
Q315		-8.4	-7.8	-4.8	60	75k	.7k	.7k	65	-
Q316		-4.0	-4.8	-8.4	36	36	65	-	60	75k
Q317		-4.0	-4.8	-8.4	36	36	65	-	60	75k
Q318		-12.5	-12	-8.4	90	300	350	200	60	-
Q319		-12.0	-12	-8.4	85	300	350	200	60	-
Q320		-12.2	-12	-8.4	90	300	350	200	60	-
Q321		-12.2	-13	-3.0	100	300	-	200	38	300
Q322		-12.0	-13	-3.0	85	300	-	200	48	300
Q323		-12.2	-13	-3.2	90	300	-	200	48	300

POWER SUPPLY MODEL 109

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		E	B	C	EMITTER		BASE		COLLECTOR	
Q501	+25v adj.	10.8	10	.40	4k	75	500	200	9k	50
Q502	+5.5v supply	-.30	.40	5.5	3	750	9k	50	44	3
Q503	+25v supply	0	-.30	-12	0	0	4	1k	3	45
Q505	+5.5v adj.	5.4	6	8.2	3	500	300	300	170	500
Q506	+5.5v supply	5.4	5.4	0	44	3	3	400	0	0
Q508	-25v supply	-25	-25	-37.5	100	110	140	300	120	130
Q509	-5.5v supply	-25	-25	-20.5	140	300	9.5k	300	100	120
Q510	-25v adj.	-14.5	-15	-25	2.5k	28	750	300	9.5k	300
Q511	-5v adj.	-4.8	-5.4	-10.5	500	65	300	750	300	350
Q512	-5.5v supply	-5.4	-4.8	-.45	42	80	500	65	14	80

4.4.3 Power Supply Calibration

As the timing circuits are dependent upon the regulated power supply voltages for reference, any variances of these voltages will necessarily cause a change in calibration accuracy. Therefore, these adjustments should not be attempted unless one is prepared to carry out complete recalibration.

Due to internal referencing within the power supply the following sequence of adjustment must be followed:

a. Disconnect all voltage jumpers from power supply to front end and output amplifier sections.

b. Disconnect one end of R511 and R532.

c. Adjust variac for 115 vac and plug in Model 109.

d. Adjust R517 for +25v, ±3%.

e. Adjust R520 for +5.5v, ±5%.

f. Load +25v to ground with 100Ω. +25v should not change more than ±0.5v.

g. Adjust variac so that ac input to Model 109 varies from 105v to 125v. +25v should not change more than ±0.5v.

h. Load +5.5v to ground with 100Ω. +5.5v should not change more than ±0.5v.

i. Adjust R538 for -25v, ±3%.

j. Adjust R541 for -5.5v, ±5%.

k. Load -25v to ground with 100Ω. -25v should not change more than ±0.5v.

l. Adjust variac so that ac input to Model 109 varies from 105v to 125v. -25v should not change more than ±0.5v.

m. Load -5.5v to ground with 100Ω. -5.5v should not change more than ±0.5v.

n. Make certain all loads are disconnected from power supply.

4.4.4 Front End Section

Connect voltage jumpers from power supply to front end section.

4.4.4.1 Clock Generator Adjustment

a. Monitor TP2 with Tektronix Type 543 scope.

b. Set Model 109 Repetition Rate Control to 4 mc position.

c. Waveform at TP2 should be negative pulse from +5.5v to +2v with rise and fall times faster than 20 nanosec.

d. Turn Repetition Rate Vernier Control, R4, to maximum clockwise position.

e. Adjust R3 for frequency of 4.4 mc.

f. Turn Repetition Rate Vernier Control, R4, to maximum counterclockwise position.

g. Adjust R2 for frequency of 360 kc.

h. Repeat steps a through g.

i. Check the upper and lower limits of each repetition rate range. Make certain that the ranges overlap each other. If the ranges do not overlap, readjust R3 and R2 the amount required for overlapping. If R2 and R3 have to be changed significantly, check timing capacitor tolerances.

j. Monitor TP2 with Tektronix Type 661 oscilloscope using a Tektronix Type P6035 passive probe (5k input impedance).

k. Set Repetition Rate Control to 40 mc position. Turn 40 mc Repetition Rate Vernier, C5, to maximum clockwise position.

l. Adjust C4 for frequency of 40 mc.

m. Turn 40 mc Vernier Control to max counterclockwise position. Frequency should be less than 4.3 mc. If frequency is greater than 4.3 mc, R5 should be increased until the frequency is less than 4.3 mc. If R5 is changed, C4 must be readjusted. R5 is a factory selected fixed resistor.

n. Turn Repetition Rate Control to -EXT position. Turn EXT Sensitivity Control (R32) to maximum clockwise position. Set Input Impedance Z Switch (S31) to the 50Ω position.

o. Adjust the Negative Output Control of a tested Model 109 for 1.5v. Couple the output to Trigger Input of Model 109 under test with 50Ω coaxial cable. Vary the frequency of tested Model 109 from 4 mc to 40 mc. The Model 109 under test should trigger reliably through the entire range.

p. Repeat step o only using a positive pulse with the Repetition Rate Control set to +EXT position. Ascertain that the unit will trigger reliably from 4 mc to 40 mc with 1.5v positive pulse.

q. Turn Input Z Control (S31) to 500Ω position. Set output of H.P. 202C Oscillator for 1.5v rms and check Model 109 for reliable triggering from 4 cps to 1 kc in both the -EXT and +EXT positions of Repetition Rate Control.

r. Turn Repetition Rate Control to Single Cycle position. Verify that one and only one pulse is generated at TP2 for every depression of the Single Cycle Pushbutton.

4.4.4.2 Sync Output Amplifier Checkout

a. Feed sync output of Model 109 to 50Ω input of Tektronix Type 661 (set trigger mode of Type 661 to -Int. Pos.).

b. Vary frequency of Model 109 from 4 mc to 40 mc.

c. The waveshape should be a negative going pulse of at least 2v amplitude with rise and fall times less than 6 nanosec. The amplitude of the pulse should not vary more than 10% from 4 mc to 40 mc. The width of the pulse should be approximately 25 nanosec and will vary with frequency. Observe the baseline and ascertain that no spurious signals (greater than ±0.1v) appear as the frequency is varied from 4 mc to 40 mc.

4.4.4.3 Gating Circuit Checkout

a. Monitor TP4 with Tektronix Type 543.

b. Set frequency of Model 109 for 4 mc.

c. Waveform at TP4 should be a negative going signal from 0v to -5v of approxi-

mately 15 nanosec in width. The rise and fall of the signal should be less than 10 nanosec.

d. Feed positive output of tested Model 109 to the Gate Input of Model 109 under test. Adjust frequency and width of tested Model 109 for 1 kc square wave. Trigger scope with sync output of tested Model 109.

e. Adjust Amplitude Control of tested Model 109 for +3.5v. The waveform at TP4 should be a burst train of pulses with a burst rate of 1 kc and a pulse rate of 4 mc.

f. Decrease amplitude of tested Model 109 to +1.5v. The waveform at TP4 should now be a continuous pulse train of 4 mc.

4.4.4.4 Delay One-Shot Checkout

a. Monitor emitter of Q20 with Tektronix Type P6035 probe of Tektronix Type 661.

b. Adjust frequency of Model 109 for 100 kc. Set Delay Control to 0.5μs position. Turn Delay Vernier to maximum counterclockwise position.

c. Adjust R91 so that positive (4v) pulse at emitter of Q20 is 0.45 μs wide (50% amplitude points).

d. Set Delay Vernier of Model 109 to maximum clockwise position.

e. Adjust R88 so that pulse width at emitter of Q20 is 5.5 μs.

f. Repeat steps c through e.

g. Set Delay Control of Model 109 to 0.05 μs position. Turn Delay Vernier to maximum clockwise position.

h. Adjust C85 for pulse width of 50 nanosec at emitter of Q20.

i. Put Tektronix Type P6035 probe of Tektronix Type 661 on TP5. There should be a positive pulse from +2v to +5v, of 10 nanosec width with rise and fall times of approximately 10 nanosec.

j. Vary Delay Vernier from maximum counterclockwise position to maximum clockwise position. Observe pulse amplitude as delay is varied and make certain that it does not vary by more than 10%. In addition, the pulse should move smoothly as a function of delay vernier and no "skipping" should occur.

k. Monitor emitter of Q20 with Tektronix 543 scope. Check the limits of each delay range. Make certain that the ranges overlap each other. If there are "holes" in the delay ranges, adjust either R88 or R91, or both to eliminate "holes". In the event that R88 or R91 have to be changed significantly (greater than 10%) from their original setting, check the tolerances of the timing capacitors.

4.4.4.5 Mixing Circuit Checkout

a. Adjust Model 109 for frequency of 4 mc. Set Delay Controls for minimum delay (both controls maximum counterclockwise). Flip Pulse Mode Switch to Single Pulse position.

b. Monitor TP6 with Tektronix 661 and P6035 probe.

c. Adjust C114 for 10 nanosec wide negative pulse of 3v amplitude.

d. Flip Pulse Mode Switch to Double Pulse position. There should be two pulses appearing at TP6. Adjust the Delay Vernier Control so that the two pulses are separated by 25 nanosec (leading edge to leading edge).

e. Adjust C111 so that the first and second pulses are of approximately equal amplitude. C111 and C114 interact slightly with each other; therefore, both must be adjusted.

f. Turn Delay Vernier of Model 109 in clockwise direction and note amplitude of both pulses as delay is advanced. The amplitudes should not change by more than 10%. If amplitudes do change more than 10%, readjust C111 and C114.

4.4.4.6 Width One-Shot Checkout

a. Adjust Model 109 for 100 kc frequency and minimum delay. Set Pulse Width Control to 0.5μs position. Monitor TP7 with Tektronix 661 and P6035 probe.

b. Turn Width Vernier Control to maximum counterclockwise position. Adjust R132 for positive 3v pulse of 0.45 μs (50% amplitude points) at TP7.

c. Turn Width Vernier Control to maximum clockwise position. Adjust R129 for 5.5 μs pulse width at TP7.

d. Repeat Steps b and c.

e. Set Width Control to 0.05 μs position. Turn Width Vernier Control to maximum clockwise position. Adjust C126 for pulse width of 50 nanosec at TP7.

f. Vary Width Vernier Control from maximum counterclockwise position to maximum clockwise position. Observe amplitude of pulse as width is varied and make certain that it does not vary by more than 10%. In addition, the pulse width should increase smoothly without hesitation or skipping.

g. Observe TP8 with Tektronix 661 and P6035 probe. Turn Width Controls of Model 109 to minimum width position. Adjust C134 for negative pulse of approximately 4v amplitude and 10 nanosec width.

h. Monitor TP7 with Tektronix 543. Check the limits of each width range. Make certain that the ranges overlap each other. If "holes" exist in the width ranges, adjust either R129 or R132, or both. The amount of readjustment required should be slight; if this is not true, check tolerances of timing capacitors.

4.4.5 Output Amplifier Section

Connect voltage jumpers from power supply to output amplifier. Trigger oscilloscope with sync output of Model 109.

4.4.5.1 Positive Output Amplifier Checkout

a. Connect Positive Output of Model 109 to Tektronix 661 50Ω input through 10:1 (20 db) attenuator.

b. Set frequency of Model 109 for 400 kc, width for 50 nanosec, and delay for 50 nanosec. Turn Positive Amplitude Control to maximum clockwise position.

c. Adjust R318 for best appearing pulse with amplitude between 10v and 12v.

d. Adjust C312 for minimum pulse aberration.

e. Check rise and fall times for less than 5 nanosec.

f. Adjust Model 109 for minimum pulse width. Vary frequency from 4 mc to 40 mc. Note frequency at which maximum width occurs. Set Model 109 to this frequency and adjust C134 for pulse width of 10 nanosec.

g. Vary Amplitude Control. Amplitude of pulse should decrease to less than 3v before distortion occurs.

4.4.5.2 Negative Output Amplifier

a. Connect Negative Output of Model 109 to Tektronix 661 50Ω input through 20 db of attenuation.

b. Set frequency for 400 kc, width for 50 nanosec, and delay for 50 nanosec. Turn Negative Amplitude Control to maximum clockwise position.

c. Adjust R339 for best appearing pulse with amplitude between 10v and 12v.

d. Adjust C346 for minimum pulse aberration.

e. Check rise and fall times for less than 5 nanosec.

f. Adjust Model 109 for minimum pulse width. Vary frequency from 4 mc to 40 mc. Note frequency at which maximum width occurs. Set Model 109 to this frequency and adjust C331 for 10 nanosec pulse width.

g. Vary Amplitude Control. Amplitude of pulse should decrease to less than 3v before distortion occurs.

4.4.6 Final Checkout

a. Set Model 109 for 4 mc frequency, minimum pulse delay, and minimum pulse width. Turn both Amplitude Controls to half setting.

b. Trigger 661 scope with sync output of Model 109. Observe positive output of Model 109 with P6035 probe directly at BNC connector. Note carefully the position at which the pulse occurs on the face of the scope. Now put probe on back of sync output BNC connector. Note position at which the sync pulse appears on face of scope. This position should lag the previous position by 10 nanosec.

c. Set frequency of Model 109 for 4 mc. Put Pulse Mode Switch to Double Pulse position. Adjust delay between first and second pulse for 25 nanosec (viewing positive output of Model 109 with 50Ω input of 661). Increase frequency until a continuous pulse train with 25 nanosec spacing is obtained (40 mc effective repetition rate). The amplitude difference between adjacent pulses should be less than ± 5%.

d. Monitor both positive and negative outputs of Model 109 on alternate channels (50Ω input) of 661. Adjust Model 109 for minimum delay and width at frequency of 40 mc. Increase pulse width until erratic operation occurs. The pulse width at which erratic operation starts should be greater than 13 nanosec. This corresponds to a duty cycle of 50%.

e. Load both positive and negative outputs of Model 109 into 50Ω. Adjust Model 109 for maximum pulse width and delay at frequency of 4 cps. Monitor both Model 109 outputs on alternate channels of Tektronix 543 and observe flat top droop on both pulses. They should exhibit less than 5% droop. Vary line voltage from 105v ac to 125v ac. There should be no significant changes (less than 3%) in any pulse characteristic as line voltage is varied.

This completes initial checkout. Unit should be aged for 24 hours and recalibrated.

4.5 SPECIFICATION VERIFICATION

The following detailed test was performed on this instrument, just prior to shipment, to confirm published specifications. Before the test was conducted, the instrument was aged for a 24 hour period and has undergone rigid examination for workmanship and appearance.

This test should be performed after every 200 hours of operation to confirm calibration status. Recalibrate and/or troubleshoot the instrument if the specifications are not verifiable.

4.5.1 Equipment Required

a. Oscilloscope, Hewlett-Packard Model 175A or equivalent (general purpose).

b. Oscilloscope, Tektronix Type 661 or equivalent (high-band pass).

c. Two 50-ohm terminations.

d. One 20-db coaxial attenuator.

e. Trigger generator (40 mc).

4.5.2 Repetition Rate

4.5.2.1 Oscillator Timing

a. Set Pulse Delay to 0.05 μs, Verniers ccw.

b. Set Pulse Width to 0.05 μs, Verniers ccw.

c. Set attenuators to 10 volts.

d. Terminate outputs into 50 ohm load.

e. Sync scope from neg. sync output.

f. View pos. output pulse and follow the panel control settings in Table 4-2.

4.5.2.2 Jitter

a. Set controls as in 4.5.2.1, (a thru d) above. Sync scope internally on +INT.

b. Set Repetition Rate to 10 mc.

c. Set Sweep Speed to 0.1μs/cm.

d. View pos. output pulse terminated into 50Ω load. One pulse should appear for each .835 cm. View the 10th pulse and expand sweep to 10ns/cm. The leading edge jitter should be less than 0.05cm, (.05%).

4.5.2.3 Stability Leave setup as in paragraph 4.5.2.2. Vary input voltage from 105v ac to 125v ac. The shift should be less than 1 cm (1%).

4.5.2.4 External Triggering Apply a ±1.5v signal from trigger generator to the external trigger input jack and verify that the instrument can be slaved up to 40 mc with repetition rate control in both Ext. + and Ext. - positions.

4.5.2.5 Sync Pulse

a. Set Delay and Width to minimum.

b. View Neg. sync pulse output into 50Ω load.

c. Sweep Repetition Rate from 4 mc to 40 mc.

d. Sync Pulse amplitude should be over 2v.

4.5.2.6 External Gate

a. Set Repetition Rate to 10 mc.

b. View pos. output pulse.

c. Apply a square wave of +3.5v in amplitude to external gate input jack with a repetition rate of 100 kc.

d. Observe that output pulses occur only during negative portion of square wave.

TABLE 4-2. REPETITION RATE CALIBRATION VERIFICATION

REP. RATE RANGE	REP. RATE VERNIER	OUTPUT PULSE WIDTH	SCOPE SWEEP SPEED/CM	PULSE SPACING
40 cps	ccw	5 ms	0.1 sec	>0.25 sec
40 cps	cw	5 ms	10 ms	<25 ms
400 cps	ccw	0.5 ms	10 ms	>25 ms
400 cps	cw	0.5 ms	1 ms	<2.5 ms
4 kc	ccw	50μs	1 ms	>2.5 ms
4 kc	cw	50μs	0.1 ms	<0.25 ms
40 kc	ccw	5μs	0.1 ms	>0.25 ms
40 kc	cw	5μs	10μs	<25μs
400 kc	ccw	0.5μs	10μs	>25μs
400 kc	cw	0.5μs	1μs	<2.5μs
4 mc	ccw	50 ns	1μs	>2.5μs
4 mc	cw	50 ns	0.1μs	<0.25μs
40 mc	ccw	10 ns	0.1μs	>0.25μs
40 mc	cw	10 ns	10 ns	<25 ns

4.5.3 Pulse Delay

4.5.3.1 Delay Timing

a. Set positive and negative Attenuators to 10v.

b. Set Repetition Rate to 400 kc, Verniers cw.

c. Sync oscilloscope from negative sync output.

d. View the sync pulse and positive pulse output (50Ω termination) simultaneously on dual trace oscilloscope.

e. Follow control settings in Table 4-3.

4.5.3.2 Delay Duty Cycle

a. Set Repetition Rate to 100 kc, Verniers cw.

b. Set Pulse Width to 0.5 μs, Verniers to cw.

c. Sync oscilloscope from negative sync output with sweep speed of 1μs/cm.

d. View positive pulse output (50Ω termination).

e. Set Delay to 5 μs, Vernier ccw. Slowly turn Vernier cw and verify that 75% delay duty cycle (7.5 μs) can be attained without circuit failure.

4.5.3.3 Delay Jitter

a. With controls set as in paragraph 4.5.3.2, (5 μs Delay), Set sweep speed to 0.5 μs/cm and expand to 50 ns/cm.

b. View leading edge of pulse and verify that jitter is less than 0.1 cm (0.1%).

4.5.3.4 Delay Stability With same setup as paragraph 4.5.3.3, vary input voltage from 105v to 125v and verify that delay change is less than 1 cm (1%).

4.5.4 Pulse Width

4.5.4.1 Pulse Width Timing

a. Set Attenuators to 10v.

b. Set Repetition Rate to 400 kc, Vernier cw.

c. Sync Oscilloscope from negative sync output.

d. View the positive pulse output (50Ω termination).

e. Follow control settings on Table 4-4.

4.5.4.2 Pulse Width Stability With the same setup as paragraph 4.5.3.3 vary line voltage from 150v to 125v and verify that pulse width change is less than 1 cm (1%).

4.5.4.3 Pulse Width Duty Cycle

a. Set Repetition Rate to 100 kc.

b. Set Pulse Delay to 0.5 μs, Vernier cw.

c. Sync oscilloscope from negative sync output with sweep speed of 1μs/cm.

d. View positive pulse output (50Ω termination).

e. Set Pulse Width to 5 μs, Vernier ccw. Slowly turn VERNIER cw and verify that 75% WIDTH duty cycle (7.5μs) can be attained without circuit failure.

TABLE 4-3. DELAY CALIBRATION VERIFICATION

DELAY RANGE	DELAY VERNIER	PULSE WIDTH	REP. RATE	SCOPE SWEEP SPEED CM	DELAY
0.05 μs	ccw	50 ns	400 kc	50 ns	>10 ns*
0.05 μs	cw	50 ns	400 kc	50 ns	>50 ns
0.5 μs	ccw	0.5 μs	40 kc	50 ns	<50 ns
0.5 μs	cw	0.5 μs	40 kc	0.1 μs	>0.5 μs
5 μs	ccw	5 μs	4 kc	0.1 μs	<0.5 μs
5 μs	cw	5 μs	4 kc	1 μs	>5 μs
50 μs	ccw	0.05 ms	400 cps	1 μs	<5 μs
50 ns	cw	0.05 ms	400 cps	10 μs	>50 μs
0.5 ms	ccw	0.5 ms	400 cps	10 μs	<50 μs
0.5 ms	cw	0.5 ms	40 cps	0.1 ms	>0.5 ms
5 ms	ccw	0.5 ms	40 cps	0.1 ms	<0.5 ms
5 ms	cw	5 ms	4 cps	1 ms	>5 ms
50 ms	ccw	5 ms	4 cps	1 ms	<5 ms
50 ms	cw	5 ms	4 cps	10 ms	>50 ms

*Advance

TABLE 4-4. WIDTH CALIBRATION VERIFICATION

WIDTH RANGE	WIDTH VERNIER	PULSE DELAY	REP. RATE	SCOPE SWEEP SPEED CM	WIDTH
0.05 μs	ccw	50 ns	400 kc	50 ns	<10 ns
0.05 μs	cw	50 ns	400 kc	50 ns	>50 ns
0.5 μs	ccw	0.5 μs	40 kc	50 ns	<50 ns
0.5 μs	cw	0.5 μs	40 kc	0.1 μs	>0.5 μs
5 μs	ccw	5 μs	4 kc	0.1 μs	<0.5 μs
5 μs	cw	5 μs	4 kc	1 μs	>5 μs
50 μs	ccw	50 μs	400 cps	1 μs	<5 μs
50 μs	cw	50 μs	400 cps	10 μs	>50 μs
0.5 ms	ccw	0.5 ms	400 cps	0.1 ms	<50 μs
0.5 ms	cw	0.5 ms	40 cps	0.1 ms	>0.5 ms
5 ms	ccw	5 ms	40 cps	1 ms	<0.5 ms
5 ms	cw	5 ms	40 cps	1 ms	>5 ms
50 ms	ccw	5 ms	40 cps	1 ms	<5 ms
50 ms	cw	5 ms	4 cps	10 ms	>50 ms

4.5.4.4 Pulse Width Jitter

a. Adjust pulse width for 5 μs. Set sweep speed to 0.5 μs/cm and expand to 50 ns/cm. Sync oscilloscope on + Int.

b. View lagging edge of pulse and verify that jitter is less than 0.1 cm (0.1%).

4.5.5 Main Pulse Output

4.5.5.1 Output Wave Shape

a. Set Repetition Rate for 100 kc.

b. Set Pulse Delay for 0.2 μs.

c. Set Pulse Width for 0.2 μs.

d. Set Attenuators for 10v.

e. Connect positive pulse output through a 20 db (10:1) coaxial attenuator into a 50Ω load.

f. Set negative attenuator to max. ccw.

g. View voltage across load with high bandpass oscilloscope (Tektronix Type 661 or equivalent).

h. Set sweep speed 50 ns/cm.

i. Set vertical sensitivity 0.2v/cm (10:1 attenuator makes 2v/cm effective). See Figure 4-5.

j. Verify that amplitude is 5 cm ± 1/4 cm (5%).

k. Verify that pulse aberrations are less than 0.25 cm (5%).

l. Set sweep speed to 2 ns/cm.

m. View leading edge and verify that rise time from 10% to 90% amplitude points is less than 5 nanosec (2.5 cm).

n. View lagging edge and verify that decay time from 90% to 10% amplitude points is less than 5 nanosec (2.5 cm).

o. Set positive attenuator to ccw. Set negative attenuator to 10 v. Connect negative pulse output through 20 db (10:1) attenuator to 50 ohm load.

p. Repeat steps g through o.

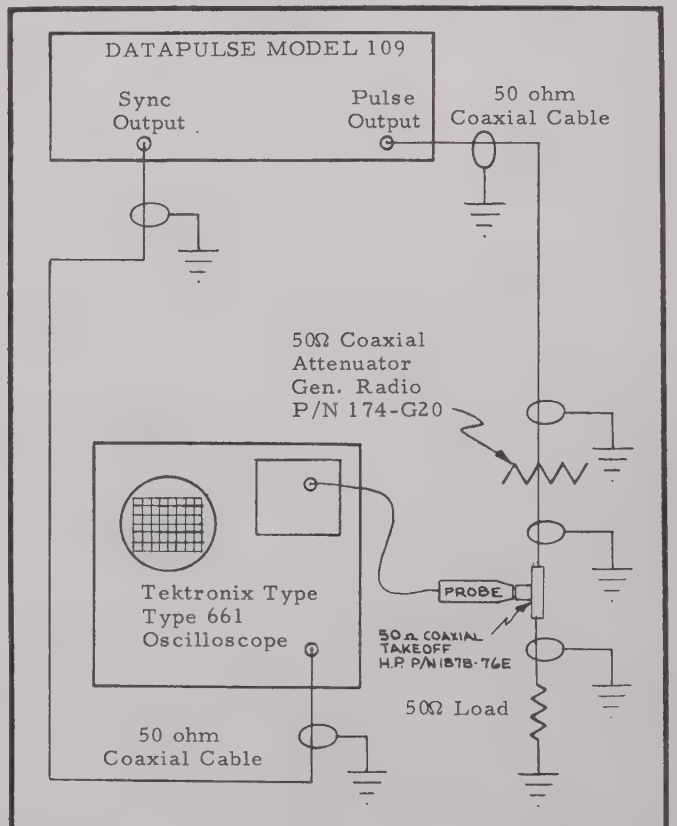


Figure 4-5. Scope Interconnections for Waveform Verification.

SECTION V
PARTS LIST

5.1 HOW TO USE THIS PARTS LIST

5.1.1 Reference Designations

Reference designations used throughout this listing correspond with reference designations given on component location photos and the following schematics:

Drawing No. J40000-100
Drawing No. J40000-101
Drawing No. J40000-102

Resistors are designated as R1, R2, R3, etc., and are fixed value, composition, 10% and 1/2 w unless otherwise noted.

Capacitors are designated as C1, C2, C3 etc., and are fixed value, 10% and 500v DC unless otherwise noted.

Diodes are designated as CR1, CR2, CR3; switches as S1, S2, S3; inductors as L1, L2, and L3; transistors are Q1, Q2, Q3, etc.

5.1.2 Abbreviations

The following abbreviations are used:

CER:	Ceramic
DPC:	Deposited Carbon
ELECT.	Electrolytic
M:	Mica
GMV:	Guaranteed Min. Value
OF:	Oil Filled
PT:	Paper Tubular
SM:	Silver Mica
VAR:	Variable
WW:	Wire Wound
PNP:	Positive-Negative-Positive
NPN:	Negative-Positive-Negative
μsec:	Microsecond
μf:	Microfarad
μh:	Microhenry
ns:	Nanosecond
ms:	Millisecond
MP:	Metalized Paper
TANT:	Tantalum
PIV:	Peak Inverse Voltage
VTQ:	Vitamin Q
PC:	Printed Circuit
Germ:	Germanium
SPDT:	Single Pole Double Throw
DPDT:	Double Pole Double Throw

5.1.3 Federal Manufacturers Code Numbers

Manufacturers of the components used in this instrument are referenced herein by Federal Supply Code numbers as listed below:

Company	Federal Code Number
Allen-Bradley	01121
Chicago Telephone	71450
General Radio	24655
Ward Leonard	63743
Sangamo	53021
MEC Inc.	None
Cornell Dublier	09023
Electro Cube	14752
Sprague	56289
Arco	02799
Comark	None
Erie	91674
Motorola	94990
Texas Instruments, Inc.	01295
Philco	98329
General Instrument	14936
Alco	95146
Centralab	71590
PCA	None
Drake	72765
ACDC	08742
Bushman	71400
Corning	07115
Melrain	08984
Magnetic Components	14931
Hughes Aircraft, SC Div.	73293
Nashville Electronics	None
Sylvania Electric	93332
Radio Corp. of America	02735
Fairchild Semiconductor	07263
General Electric	03508
Mallory	37942
Hoffman Semiconductor	99942
Technitrol Engineering	90095
Elco	91662
Wilco	99818
Oak	81716
Lafayette Radio	75491
Pacific Semiconductors	01281
Datapulse Incorporated	15933
Elmenco Products	04062
Capco Corporation	04099
Texas Capacitor	09134
Switchcraft Inc.	82389
Ohmite Mfg. Company	03615
General Instruments	91719
Wilco Company	79327
Beckman Instruments	80740

PARTS LIST

5.1 MAIN CIRCUIT BOARD

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.1	Resistors						
R1	1	100k, 1/4w, 5%	10010-104	01121	CB1045		
R2	1	250, .2w, 30%, PC Mntg.	20240-254	71450	Series UPE 70		
R3	1	10k, .2w, 30%, PC Mntg.	20240-103	71450	Series UPE 70		
R5	8	270Ω, 1/4w, 5%	10010-271	01121	CB2715		
R6	4	1k, 1/4w, 5%	10010-102	01121	CB1025		
R7	1	6.8k, 1/4w, 5%	10010-682	01121	CB6825		
R8		Same as R 5					
R9	4	2.7k, 1/4w, 5%	10010-272	01121	CB2725		
R10	5	330Ω, 1/4w, 5%	10010-331	01121	CB3315		
R11	24	47Ω, 1/4w, 5%	10010-470	01121	CB4705		
R12	5	3.9k, 1/4w, 5%	10010-392	01121	CB3925		
R13		Same as R12					
R14		Same as R12					
R15	3	10k, 1/4w, 5%	10010-103	01121	CB1035		
R16		Same as R15					
R17		Same as R11					
R18	2	12k, 1/4w, 5%	10010-123	01121	CB1235		
R19	2	1.5k, 1/4w, 5%	10010-152	01121	CB1525		
R20	3	8.2k, 1/4w, 5%	10010-822	01121	CB8225		
R21	2	150Ω, 1/4w, 5%	10010-151	01121	CB1515		
R22	2	1.5k, 1w, 5%	10011-152	01121	GB1525		
R23		Same as R6					
R24	6	4.7k, 1/4w, 5%	10010-472	01121	CB4725		
R25	4	180Ω, 1/4w, 5%	10010-181	01121	CB1815		
R26	4	1.8k, 1/4w, 5%	10010-182	01121	CB1825		
R27		Same as R26					
R28		Same as R12					
R29	1	82Ω, 1/4w, 5%	10010-820	01121	CB8205		
R31	1	51Ω, 5%	10011-510	01121	EB5105		
R33	2	2.2k, 1/4w, 5%	10010-222	01121	CB2225		
R34		Same as R33					
R35		Same as R24					
R36		Same as R11					
R37		Same as R22					
R38	4	22Ω, 1/4w, 5%	10010-220	01121	CB2205		
R39	4	390Ω, 1/4w, 5%	10010-391	01121	CB3915		
R40		Same as R11					
R41		Same as R11					
R50	4	100Ω, 1/4w, 5%	10010-101	01121	CB1015		
R51	1	3.3k, 5%	10011-332	01121	EB3325		
R52		Same as R21					
R53		Same as R24					
R54	4	220Ω, 1/4w, 5%	10010-221	01121	CB2215		
R55		Same as R54					
R56		Same as R5					
R57		Same as R5					
R58		Same as R38					
R59	2	820Ω, 1/4w, 5%	10010-821	01121	CB8215		
R60		Same as R54					
R61		Same as R12					
R62		Same as R11					
R63		Same as R54					
R64		Same as R39					
R65		Same as R50					
R66		Same as R11					
R67		Same as R18					
R68		Same as R5					
R69		Same as R5					
R70	7	10Ω, 1/4w, 5%	10010-100	01121	CB1005		
R71		Same as R59					

PARTS LIST

5.1 MAIN CIRCUIT BOARD--cont.

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.1		Resistors--cont.					
R80		Same as R39					
R81		Same as R11					
R82		Same as R24					
R83		Same as R11					
R84		Same as R6					
R85		Same as R10					
R86	6	1.8k, 5%	10011-182	01121	EB1825		
R87	2	33k, 1/4w, 5%	10010-333	01121	CB3335		
R88	2	500k, .2w, 30%	20240-504	71450	Series UPE 70		
R89		Same as R11					
R90		Same as R86					
R91	2	5k, .2w, 30%, p.c. mntg.	20240-502	71450	Series UPE 70		
R93		Same as R11					
R94	6	470Ω, 1/4w, 5%	10010-471	01121	CB4715		
R95		Same as R50					
R96		Same as R50					
R97		Same as R11					
R98		Same as R11					
R99		Same as R86					
R100		Same as R9					
R101		Same as R10					
R102		Same as R94					
R111		Same as R11					
R112		Same as R24					
R113		Same as R10					
R114		Same as R94					
R115		Same as R11					
R116		Same as R94					
R117		Same as R11					
R118		Same as R94					
R119		Same as R5					
R120	1	3.3k, 1/4w, 5%	10010-332	01121	CB3325		
R121		Same as R39					
R122		Same as R25					
R123		Same as R24					
R124		Same as R11					
R125		Same as R6					
R126		Same as R10					
R127		Same as R86					
R128		Same as R87					
R129		Same as R88					
R130		Same as R11					
R131		Same as R86					
R132		Same as R91					
R134		Same as R11					
R135		Same as R86					
R136		Same as R11					
R137		Same as R94					
R138		Same as R11					
R139		Same as R26					
R140		Same as R20					
R141		Same as R25					
R142		Same as R38					
R301		Same as R11					
R302	6	33Ω, 1/4w, 5%	10010-330	01121	CB3305		
R303		Same as R11					

PARTS LIST

5.1 MAIN CIRCUIT BOARD--cont.

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.1		Resistors--cont.					
R304		Same as R302					
R305		Same as R70					
R306		Same as R70					
R307		Same as R70					
R308	1	470Ω, 1w, 5%	10012-471	01121	GB4715		
R309-311	6	150Ω, 2w, 5%	10013-151	01121	HB1515		
R312		Same as R302					
R313	1	2.7k, 5%	10011-272	01121	EB2725		
R314	6	2.7Ω, 1/4w, 5%	10010-279	01121	CB2795		
R315		Same as R314					
R316		Same as R314					
R317		Same as R9					
R318	6	0.2w, 30%, PC Mntg.	20240-102	71450	Series UPE70		
R319		Same as R19					
R320	4	39Ω, 2w, 5%	10013-390	01121	HB3905		
R321		Same as R320					
R323	1	15k, 1/4w, 5%	10010-153	01121	CB1535		
R331		Same as R26					
R332		Same as R20					
R333		Same as R38					
R334		Same as R25					
R335		Same as R5					
R336		Same as R302					
R337		Same as R332					
R338		Same as R9					
R339		Same as R318					
R340	1	1.2k, 1/4w, 5%	10010-122	01121	CB1225		
R341		Same as R320					
R342		Same as R320					
R343		Same as R15					
R344		Same as R11					
R345		Same as R302					
R346		Same as R70					
R347		Same as R70					
R348		Same as R70					
R349	1	390Ω, 12w, 5%	10012-931	01121	GB3915		
R350-352		Same as 309					
R353		Same as R302					
R354	5	1k, 5%	10011-102	01121	EB1025		
R355		Same as R314					
R356		Same as R314					
R357		Same as R314					
R361		Same as R327					
R510	2	1Ω, 3w, 5%	10264-109	56289	450E1R05		
R511	2	50Ω. 5w, 5%	10264-500	56289	452E5005		
R512	2	5Ω, 5w, 5%	10304-509	56289	5F5WL		
R513	2	680Ω, 5%	10011-681	01121	EB6810		
R514	2	10k, 5%	10011-103	01121	EB1035		
R515	2	4.7k, 5%	10011-472	01121	EB4725		
R516		Same as R354					
R517		Same as R318					
R518	3	470Ω, 5%	10011-471	01121	EB4715		
R519	2	2.2k, 5%	10011-222	01121	EB2225		
R520		Same as R318					
R521	2	330Ω, 5%	10011-331	01121	EB3315		
R522		Same as R354					
R523		Same as R518					
R524	2	1.5k, 5%	10011-152	01121	EB1525		
R525	1	75Ω, 10w, 5%	10305-750	63743	10F7SWL		
R531		Same as R510					
R532		Same as R511					

PARTS LIST

5.1 MAIN CIRCUIT BOARD--cont.

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.1		Resistors--cont.					
R533		Same as R512					
R534		Same as R513					
R535		Same as R514					
R536		Same as R515					
R537		Same as R518					
R538		Same as R318					
R539		Same as R354					
R540		Same as R519					
R541		Same as R318					
R542		Same as R521					
R543		Same as R354					
R544	1	560Ω, 5%	10011-561	01121	EB5615		
R545		Same as R524					
R546	1	27Ω, 2w, 5%	10723-270	07115	Type C-42		
R547	1	47Ω, 10w, 5%	10305-470	03615	3770		
R548	1	18Ω, 1w, 5%	10012-180	01121	GB1805		

PARTS LIST

5.1 MAIN CIRCUIT BOARD

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.2		Capacitors					
C1	3	Cer. Disc., .1μf, 75v	11242-104	71590	DDA-104		
C2	21	100μf, 35v	11162-107	Nashville Elect.	20-500BP100-35S85		
C3	38	Cer, Disc., .05μf, 25v	11241-503	91674	5855		
C4	5	Cer. 7-25pf, 35v	11305-250	91674	538-000		
C12	6	47 pf, 5%, S. M.	11017-470	00853	RR1447		
C13		Same as C3					
C14		Same as C12					
C15		Same as C3					
C16	3	27 pf, 5%	11017-270	00853	RR1427		
C17	3	1μf, 50v	11159-105	Nashville	11-215BP1-50D65		
C18		Same as					
C31		Same as C12					
C32		Same as C12					
C33		Same as C3					
C34		Same as C3					
C50	2	100pf, 5%	11017-101	53021	RR1310		
C51		Same as C3					
C52		Same as C12					
C53		Same as C3					
C62		Same as C3					
C64		Same as C50					
C65		Same as C3					
C61, 63		Same as C16					
C80		Same as C3					
C81	1	15pf, 5%	11017-150	53021	RR1415		
C82		Same as C3					
C83		Same as C1					
C84		Same as C3					
C85		Same as C4					
C92		Same as C3					
C93		Same as C3					
C110		Same as C12					
C111		Same as C4					
C112		Same as C3					
C113		Same as C3					
C114		Same as C4					
C115		Same as C3					
C121		Same as C3					
C122	1	33pf, 5%	11017-330	53021	RR1433		
C123		Same as C3					
C124		Same as C1					
C125		Same as C3					
C126		Same as C4					
C133		Same as C3					
C134	2	Cer. 4-30pf	11307-300	91674	503-000		
C135		Same as C3					
C301		Same as C2					
C302		Same as C3					
C303		Same as C2					
C304-308		Same as C3					
C310		Same as C17					
C311		Same as C2					
C331		Same as C134					
C332		Same as C3					
C333		Same as C3					

PARTS LIST

5.1 MAIN CIRCUIT BOARD

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.2		Capacitors--cont.					
C334		Same as C17					
C335		Same as C3					
C336		Same as C2					
C337-339		Same as C3					
C340		Same as C2					
C341		Same as C2					
C342-345		Same as C3					
C510	2	1500 μf, 50v	11162-158	53021	Type 505		
C511-517		Same as C2					
C531		Same as C510					
C532-538		Same as C2					

PARTS LIST

5.1 MAIN CIRCUIT BOARD

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.3		Transistors					
Q1	1	Ger. PNP	12605-005	07263	2N3638		
Q2	30	NPN	22635-003		DP63-3		
Q3	3	Same as Q2					
Q4		Same as Q2					
Q5	10	Ger. PNP	22605-006		DP60-6		
Q6		Same as Q5					
Q7-9		Same as Q2					
Q10		Same as Q5					
Q11		Same as Q5					
Q12-18		Same as Q2					
Q19		Same as Q5					
Q20	1	NPN	22635-004		DP63-4		
Q21-24		Same as Q2					
Q25		Same as Q5					
Q26		Same as Q2					
Q27		Same as Q2					
Q28		Same as Q5					
Q29		Same as Q2					
Q30		Same as Q2					
Q301		Same as Q5					
Q302		Same as Q5					
Q303-305		Same as Q2					
Q306	4	PNP, 20v	22605-0014		DP60-14		
Q307		Same as Q306					
Q308		Same as Q306					
Q309	5	PNP, .6w, 45v	22595-000		DP59-0		
Q310	7	NPN, 40v, .6w	12685-004	94990	SM1330		
Q311		Same as Q310					
Q312		Same as Q2					
Q313		Same as Q5					
Q314		Same as Q306					
Q315		Same as Q310					
Q316		Same as Q309					
Q317		Same as Q309					
Q318-323		Same as Q2					
Q501		Same as Q309					
Q502		Same as Q310					
Q505		Same as Q310					
Q506	1	Ger. PNP	12455-008	94990	2N1535		
Q509		Same as Q310					
Q510		Same as Q309					
Q511		Same as Q1					
Q512		Same as Q310					
5.1.4		Diodes					
CR1	39	Mesa, 40v	22164-000		DP16-0		
CR2		Same as CR1					
CR3	9	Ger. Gold Bonded	12144-003	93332	1N995		
CR4		Same as CR3					
CR5		Same as CR1					
CR6		Same as CR1					
CR31		Same as CR1					
CR32		Same as CR1					
CR50		Same as CR1					
CR51		Same as CR3					

PARTS LIST

5.1 MAIN CIRCUIT BOARD

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.1.4		Diodes--cont.					
CR61-66		Same as CR1					
CR80		Same as CR1					
CR81		Same as CR1					
CR82		Same as CR3					
CR83		Same as CR1					
CR84		Same as CR1					
CR85		Same as CR3					
CR86		Same as CR3					
CR87		Same as CR1					
CR111, 114		Same as CR1					
CR115		Same as CR1					
CR116		Same as CR1					
CR121		Same as CR1					
CR122		Same as CR1					
CR123		Same as CR3					
CR124		Same as CR1					
CR125		Same as CR3					
CR301-305		Same as CR1					
CR306	17	Axial Leads	22194-001		DP-19-1		
CR307		Same as CR306					
CR308		Same as CR306					
CR309-311		Same as CR1					
CR331		Same as CR3					
CR332		Same as CR1					
CR333		Same as CR1					
CR334	1	Zener, Silicon, 400mw, 10%, 6.8v	12154-026	Continental Devices	1N754		
CR335-340		Same as CR306					
CR341-343		Same as CR1					
CR510-513		Same as CR306					
CR514	2	Zener, 15v, 1w, 5%	12154-017	37942	ZA158		
CR531-534		Same as CR306					
CR535		Same as CR514					
5.1.5		Miscellaneous					
5.1.5.1		Indicators					
L1	1	Phenolic core, 1.5µh	14234-005	99818	207-11		
L2	4	RF choke, .68µh, 10%	14262-000	Nytronics	SWDO.68		
L3	6	Phenolic core, 1µh	14284-002	99818	205-11-10		
L31	2	Phenolic core, 2.7µh	14284-006	99818	210-11		
L50		Same as L31					
L61-63		Same as L3					
L80		Same as L2					
L81		Same as L2					
L111		Same as L2					
L112		Same as L3					
L121		Same as L3					
DL50		Delay Line, 50 nanosec, 200Ω, ±10%	14185-000	Video Color	A1142A		
DL80		Delay Line	30000-018	15933			

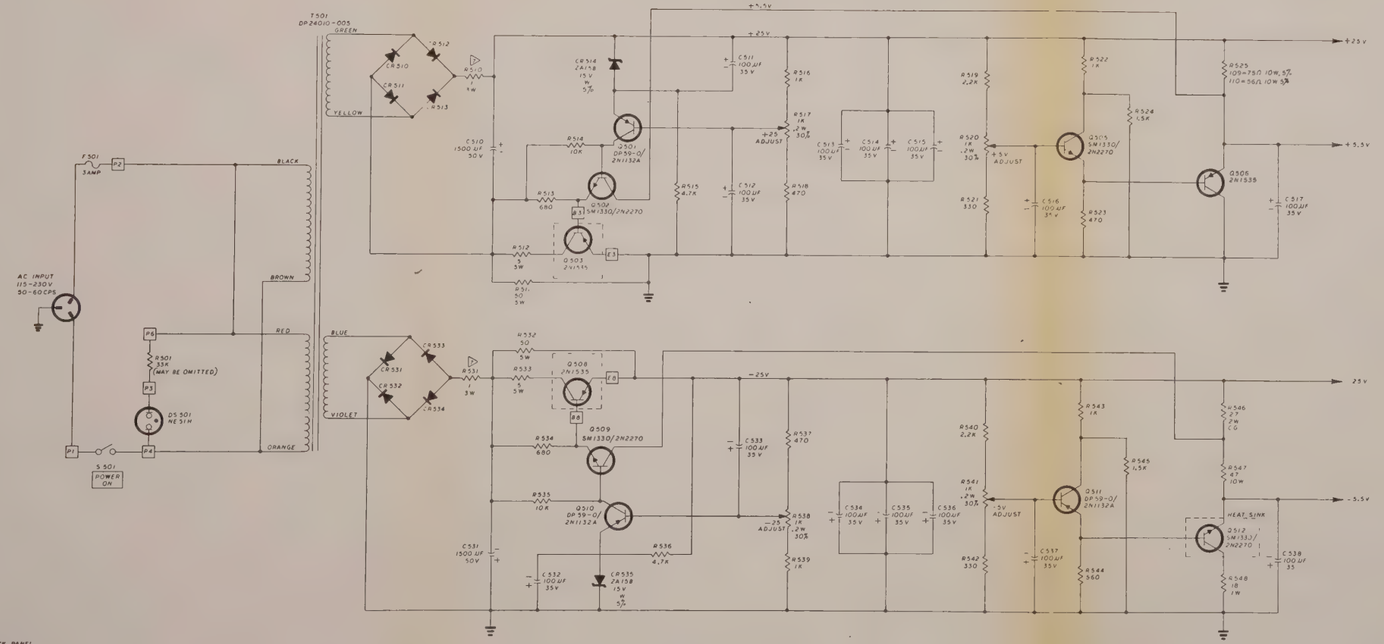
PARTS LIST

5.2 FRONT PANEL ASSEMBLY

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.2.1	Resistors						
R32	1	1k. 2w	20053-102	01121	Jain 056S102U		
R324	2	Met. Film, 51Ω, 2w, 5%	10723-510	07115	Type C42		
R325	2	51Ω, 5%	10011-510	01121	EB5105		
R326	2	Bridge "T", 50Ω,2w, 20%	20213-500S	01121	Type JJ		
R327	2	100Ω, 5%	10011-101	01121	EB1015		
R358		Same as R324					
R359		Same as R325					
R360		Same as R326					
R361		Same as R327					
5.2.2	Capacitors						
C19	1	Disc. Cer. 0.1μf, 75v	11242-104	71590	DDA-104		
C312	2	Cer. 4-30 P.F.	11307-300	91674	503-000		
C346		Same as C312					
5.2.3	Switches						
S2	1	Push button, red, spdt.	15300-001	82389	903-1C-Red		
S31	3	Toggle, spdt. Micro-Min.	15280-001	95146	Mst. 115D		
S111		Same as S31					
S501		Same as S31					
5.3	OSCILLATOR SWITCH ASSEMBLY						
5.3.1	Resistors						
R4	1	Var., 150k, 2w	20053-154				
5.3.2	Capacitors						
C5	1	Var., 5-320pf	11292-321	Mitsumi Elect.	PVC-ZK		
C6	1	Var., 33μf, 10v	11510-336	53021	CS13-AC-33OK		
C7	1	Tantalum, 3.3μf, 10v	11510-335	56289	1500335X9010A2		
C8	1	Met. Mylar, .33μf, 200v 2%	11124-334	14752	210B1C334G		
C9	1	Met. Mylar, .033μf, 200v 2%	11124-333	14752	210BIC333G		
C10	1	Mica, 2700pf, 2%	11047-272	53021			
C11	1	S.M., 150pf, 5%	11017-151	53021	RR1315		
5.3.3	Switches						
S1	1	Rotary, 10 position	25250-032				

5.4 DELAY AND WIDTH SWITCH ASSEMBLIES

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
5.4.1		Resistors					
R92	2	Var., 100k, 2w (Delay)		01121	Type J		
R133		Same as R92 (Width)					
5.4.2		Capacitors					
C86	2	S.M., 82pf, 5% (Delay)		53021	RR1482		
C87	2	S.M., 1000pf, 300v, 1% (Delay)		53021	CR1210		
C88	2	S.M., 10µf, 300v, 1% (Delay)		53021	CR1110F		
C89	2	Mylar, .1µf, 200v, 1% (Delay)		14752	210B1C104F		
C90	2	Elect., 1µf, 200v, 1% (Delay)		14752	210B1C105F		
C91	2	Tantalum, 10µf, 20v, (Delay)		56289	150D106X902082		
C127		Same as C86 (Width)					
C128		Same as C87 (Width)					
C129		Same as C88 (Width)					
C130		Same as C89 (Width)					
C131		Same as C90 (Width)					
C132		Same as C91 (Width)					
5.4.3		Switches					
S80	2	Rotary, 7 position		81716			
S121		Same as S80					
5.5		BACK PANEL ASSEMBLY					
5.5.1		Transistors					
Q503	2	Silicon NPN, high voltage			ZN1535		
Q508		Same as Q503					
5.5.2		Miscellaneous					
Fuse		3 amp, fast blow, 250v		Littlefuse	8AG-1, Series 362		



▷ — NOT USED IN MODEL 110

6 — Q503 Q508 ARE MOUNTED ON BACK PANEL
3—CONNECT BROWN AND RED WIRES
2—BREAK CONNECTION BETWEEN BROWN AND ORANGE WIRES
1—BREAK CONNECTION BETWEEN BLACK AND RED WIRES
FOR 230 VAC OPERATION

5 — T501 IS SHOWN CONNECTED FOR 115 VAC OPERATION

4 — BOXED LETTERS AND/OR NUMBERS INDICATE SPECIFIC POINTS ON CIRCUIT BOARD

3 — BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE

2 — ALL DIODES ARE DP19-1/1N4002

1 — ALL RESISTORS ARE IN OHMS 1/2W,5%

NOTES: UNLESS OTHERWISE SPECIFIED

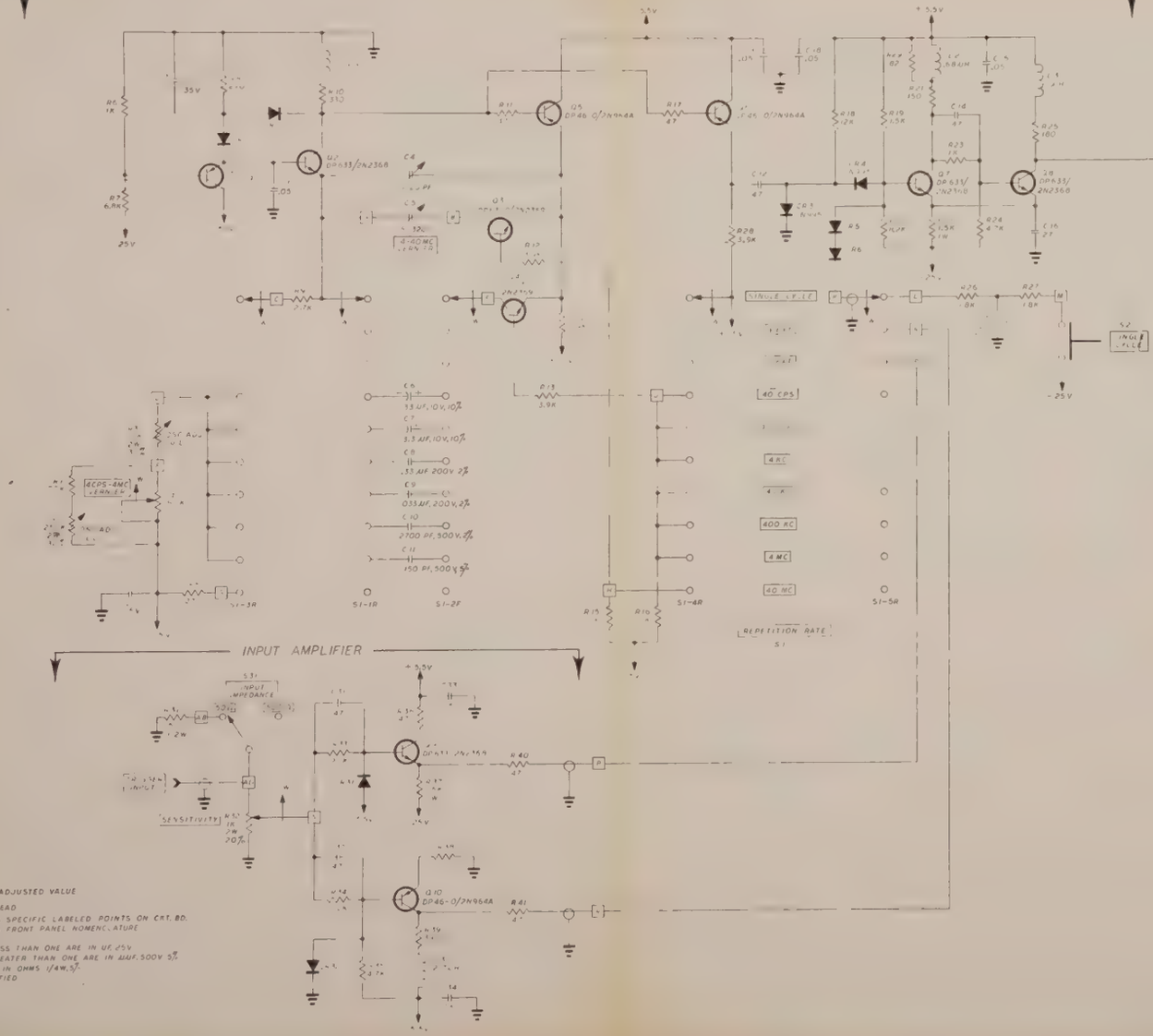
C510	DS501	
C511	S501	
C512	F501	
Q501	Q502	2N1132
CR510	CR511	1N4002
C510	C512	25V
R510	R525	1W 5%
R531	R532	1W 5%

SCHEMATIC — POWER SUPPLY MODEL 109 & 110

KRONE 10004 JAPAN

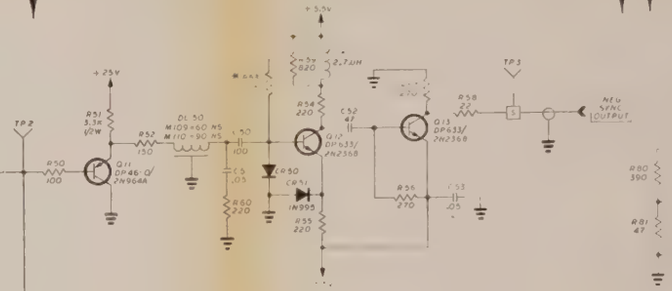
10000-100

CLOCK GENERATOR

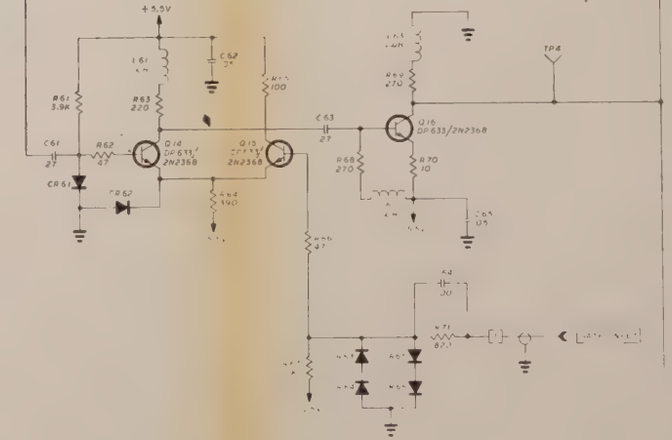


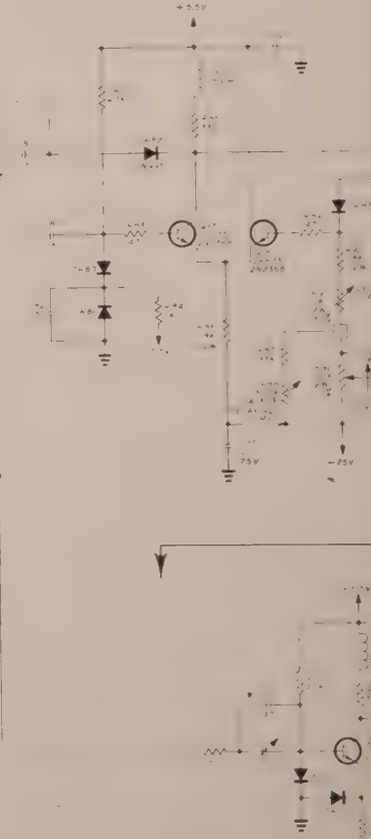
INPUT AMPLIFIER

SYNC OUTPUT AMPLIFIER



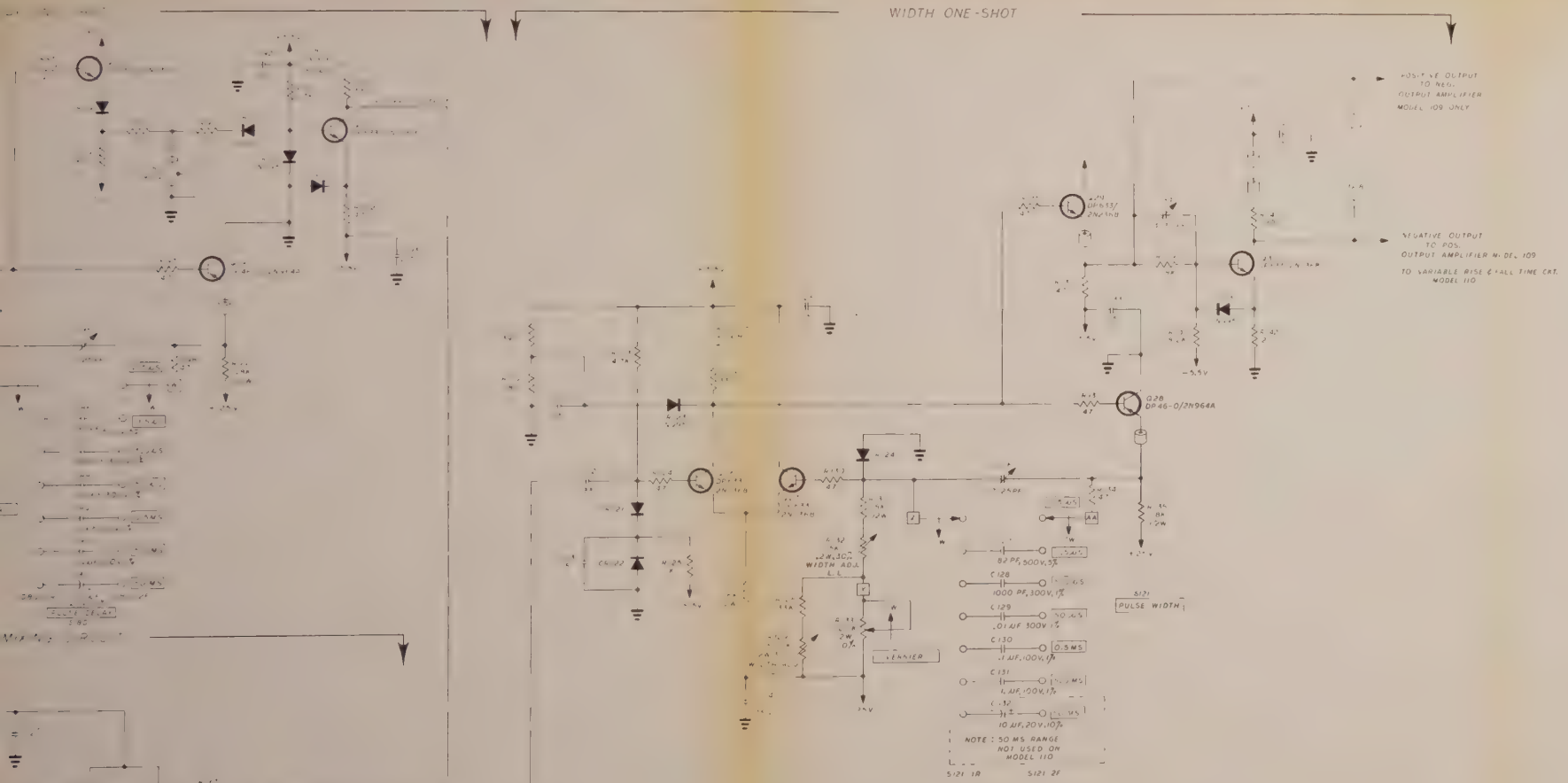
GATING AMPLIFIER





- ● INDICATES A FACTORY ADJUSTED VALUE
- INDICATES A FERRITE BEAD
- LETTERS INDICATES SPECIFIC LABELED POINTS ON CRT. BD.
- W +DING INDICATES FRONT PANEL NOMENCLATURE
- DES ARE DP16-0
- CAPACITOR VALUES LESS THAN ONE ARE IN UF, 25V
- CAPACITOR VALUES GREATER THAN ONE ARE IN UUF, 500V 5%
- RESISTOR VALUES ARE IN OHMS 1/4W, 5%
- ± 5% OTHERWISE SPECIFIED

WIDTH ONE-SHOT


POSITIVE OUTPUT TO NEG. OUTPUT AMPLIFIER MODEL 109 ONLY
NEGATIVE OUTPUT TO POS. OUTPUT AMPLIFIER MDL. 109
TO VARIABLE RISE & FALL TIME CKT. MODEL 110
Q28 DP46-0/2N964A
-5.5V
+24V
2K, 30 WIDTH ADJ.
VERNIER
82 PF, 500V, 5%
C128 1000 PF, 300V, 1%
C129 .01 MF 300V 1%
C130 .1 MF, 100V, 1%
C131 1 MF, 100V, 1%
10 MF, 20V, 10%
0.5 MS
NOTE: 50 MS RANGE NOT USED ON MODEL 110
5121 1A
5121 2F
5121 PULSE WIDTH

REVISIONS				
LTR	SYM	DESCRIPTION	DATE	APPROVED
013	A	CORRECTED ERRORS & RELEASED	10 JAN 69	

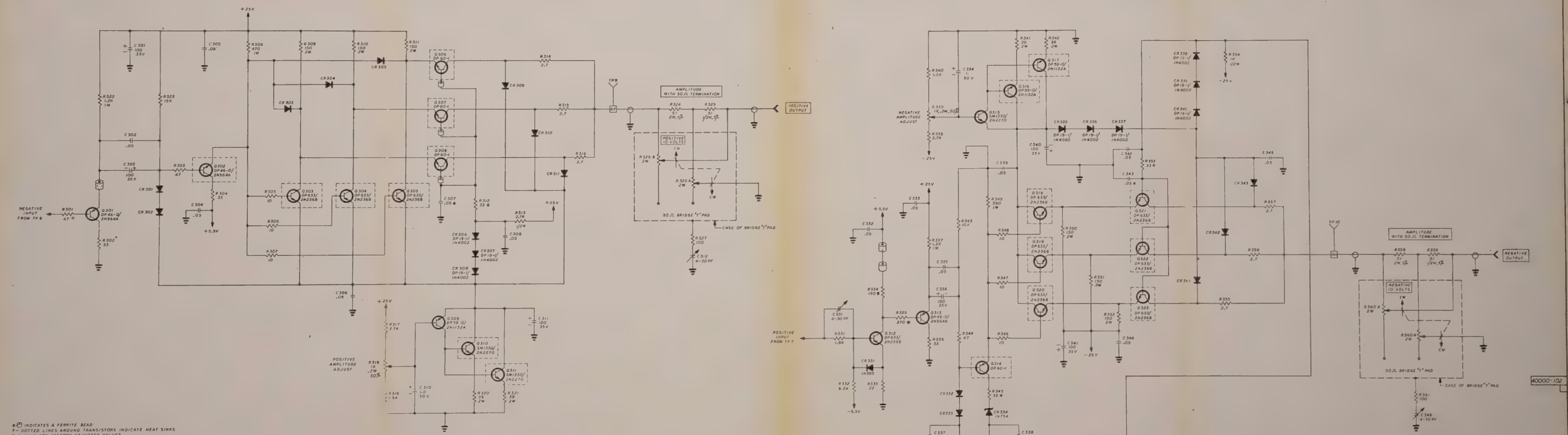
	C 2	L4 30, 32-49, 51-60, 64-79 82-110, 115-120
Q 30		
Q 42*		C87-30, 33-49, 52-60, 67-79 88-110, 117-120
C 35*		C 19-30, 35-49, 54-60, 66-79 84-109, 116-120.
R 132		R 30, 32, 42-49, 72-79 103 110,
LAST USED		OMITTED
REFERENCE DESIGNATIONS		

DRAWN	BRESIN
CHECKED	
ENGINEER	
APPROVED	
SCALE	NONE
SIZE	A
CODE	19933

SCHEMATIC — FRONT END MODEL 109 & 110

40000-101

40000-101


POSITIVE OUTPUT AMPLIFIER
NEGATIVE OUTPUT AMPLIFIER
+25V
-25V
+5.5V
-5.5V
AMPLITUDE WITH 50Ω TERMINATION
POSITIVE OUTPUT
NEGATIVE OUTPUT
POSITIVE 10 VOLTS
NEGATIVE 10 VOLTS
50Ω BRIDGE "T" PAD
CASE OF BRIDGE "T" PAD
NEGATIVE INPUT FROM TP8
POSITIVE INPUT FROM TP7
POSITIVE AMPLITUDE ADJUST
NEGATIVE AMPLITUDE ADJUST
TP9
TP10
Q301 DP46-0/2N964A
Q302 DP46-0/2N964A
Q303 DP633/2N2368
Q304 DP633/2N2368
Q305 DP633/2N2368
Q306 DP60-1
Q307 DP60-1
Q308 DP60-1
Q309 DP59-0/2N1132A
Q310 SM1330/2N2270
Q311 SM1330/2N2270
Q312 DP633/2N2368
Q313 DP46-0/2N964A
Q314 DP60-1
Q315 SM1330/2N2270
Q316 DP59-0/2N1132A
Q317 DP59-0/2N1132A
Q318 DP633/2N2368
Q319 DP633/2N2368
Q320 DP633/2N2368
Q321 DP633/2N2368
Q322 DP633/2N2368
Q323 DP633/2N2368
CR301 CR302 CR303 CR304 CR305 CR306 CR307 CR308 CR309 CR310 CR311
CR331 IN595
CR332 CR333
CR334 IN754
CR335 CR336 CR337 CR338 CR339 CR340 CR341 CR342 CR343
C301 100 35V
C302 .05
C303 100 35V
C304 .05
C305 .08
C306 .05
C307 .05
C308 .05
C309 .05
C310 1.0 50V
C311 100 35V
C312 4-30 PF
C331 .05
C332 .05
C333 .05
C334 1. 50V
C335 .05
C336 100 35V
C337 .05
C338 .05
C339 .05
C340 100 35V
C341 100 35V
C342 .05
C343 .05
C344 .05
C345 .05
C346 4-30 PF
R301 47 *
R302 * 33
R303 47
R304 33
R305 10
R306 470 1W
R307 10
R308 10
R309 150 2W
R310 150 2W
R311 150 2W
R312 33 *
R313 2.7K 1/2W
R314 2.7
R315 2.7
R316 2.7
R317 2.7K
R318 1K .2W 30%
R319 1K
R320 39 2W
R321 39 2W
R322 1.2K 1W
R323 15K
R324 51 2W, 5%
R325 51 1/2W, 5%
R326 * 2W
R326A 2W
R327 100
R331 1.8K
R332 8.2K
R333 22
R334 180 *
R335 270 *
R336 33
R337 1.2K 1W
R338 2.7K
R339 1K, 2W, 30%
R340 1.2K
R341 39 2W
R342 39 2W
R343 10.1
R344 47
R345 33 *
R346 10
R347 10
R348 10
R349 390 1W
R350 150 2W
R351 150 2W
R352 150 2W
R353 33 *
R354 1K 1/2W
R355 2.7
R356 2.7
R357 2.7
R358 51 2W, 5%
R359 51 1/2W, 5%
R360 * 2W
R360A 2W
R361 100
NOTES: UNLESS OTHERWISE SPECIFIED
7— DOTTED LINES AROUND TRANSISTORS INDICATE HEAT SINKS
6— * ITEMS ARE FACTORY ADJUSTED VALUES
5— BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CKT. BD.
4— BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE
3— ALL DIODES ARE DP16-0/IN400
2— ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF, 75V
1— ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 5%
8— INDICATES A FERRITE BEAD
SCHEMATIC— OUTPUT AMPLIFIER MODEL 109
40000-102
Q 301 | Q 323 | CR 312-330
CR 301 | CR 343 | C 309, 312-330
C 301 | C 346 | R 328-330
R 301 | R 351
FIRST USED | LAST USED | OMITTED
REFERENCE DESIGNATIONS
NONE

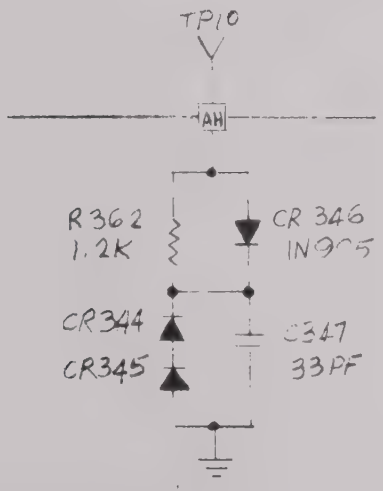
ADDENDA AND ERRATA

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
841	2-10-66	J40000-102NC	Schematic, Output Amplifier 1. To note 8 add the following: "P/N 19170-000". 2. Add note 8a: "Indicates half a bead. P/N 19170-001". 3. Add 1/2 a bead P/N 19170-001 to the base of Q306, 307 and 308. 4. Add one full bead P/N 19170-000 to emitter of Q314. 5. Add one full bead P/N 19170-000 to base of Q321, 322 and 323.
883	4-6-66	J40000-101A	Schematic, Front End. 1. Change Q5, 6, 10, 11, 19, 25 and 28 from DP46-0 to DP60-6. 2. Change CR115 and 116 from IN995 to DP16-0.
		J40000-102	Schematic, Output Amplifier. 1. Change Q301, 302 and 313 from DP46-0 to DP60-6.
2014	5-13-66	J40000-101A	Schematic, Front End. 1. Change Q3 and 4 from DP63-0 to DP63-3. 2. Change Q20 from DP63-0 to DP63-4.
2030	6-13-66	J40000-101	Schematic - Front End. Add Note 10: "DP60-6 may be 2N-3640."
		J40000-102	Schematic - Output Amplifier. Add Note 9: "DP60-6 may be 2N-3640.
2042	6-24-66	J40000-101A	Schematic - Front End. 1. Add a 10Ω, 1/4w, 5% resistor, P/N 10010-100 in series with C9 and assign ref. des. R30. 2. Change ref. des. block A/C to Item 1. 3. Change R5, 270Ω, 1/4w, 5% P/N 10010-271 to 1.3k, 1/4w, 5%, P/N 10010-132 and place an asterisk after value. 4. Change R53, 4.7k, 1/4w, 5% P/N10010-472 to 10k, 1/4w, 5%, P/N 10010-103.

ADDENDA AND ERRATA

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
2042	6-24-66	J40000-102	Schematic - Output Amplifier. Change Q306-308. Transistor DP60-1, P/N 22605-005 to DP60-4, P/N 22605-004.
2057	7-18-66	Photograph	UL and LL Oscillator adjustments shown in Figure 4-2 (page 4-3) should be reversed, i.e., R2, OSC, LL; R3, OSC, UL.
2021	8-26-66	Transistor Equiv.	SM 1330, P/N 12685-004 is an acceptable substitute for DP63-6, P/N 22635-006.
2081	8-26-66	Transistor Substitution	2N2102, P/N 12685-005 may be used in lieu of 2N2270, P/N 12695-001.
2145	12-6-66	J40000-100A	Schematic - Power Supply. 1. In general notes, add note 8 with "diamond" symbol = "Electrically equivalent parts and/or combination may be substituted." 2. Add note 8 with "diamond" symbol to R547.
		L/M37000-308	Ass'y. - Main Circuit Board. Add following note to Item 106: Allowable substitution for R547: 50Ω, 10 W, 5%, P/N 10305-500 in parallel with a 750Ω, 1 W, 5%, P/N 10012-751.
2171	1-3-67	Manual	Model cabinet is changed from color beige to color russet cardinal.
2194	1-27-67	J40000-100A	Schematic - Power Supply Change R525, 75Ω, 10 W, 5%, P/N 10305-750 to 56Ω, 10 W, P/N 10305-560.
2194A	2-2-67	J40000-100A	Schematic - Power Supply. Parallel R525, 75Ω, 10 W, 5%, P/N 10305-751 with a 220Ω, 2 W, 5%, P/N 10013-221 is electrically acceptable substitution.

ADDENDA AND ERRATA

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
2208	2-14-67	J40000-102 Zone 4	Schematic - Output Amplifier Add the following circuit from (boxed) AH (TP10).  R362 1/4W. 5%. P/N 10010-122 C347, 33PF 500V. 5% P/N 11017-330 CR346 IN995. P/N 12144-003 CR344, 345. DP16-0/IN3600 P/N 22164-000
2367	11-13-67	SB 1-65	Transistor 2N2369A P/N 22635-003 is an acceptable substitute for DP63-4 P/N 22635-004.
2359	11-18-67	SB 1-65	NPN Transistor equivalent: RCA 38880 is an acceptable equivalent for RCA 40250.

ADDENDA AND ERRATA

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
2418	2-21-68	J40000-102	Schematic - Output Amp. 1. Install a 1/2 bead P/N 19170-001 on C307 (at Junction of C307 and R312) 2. Install a 0.05UF Cap (C309) P/N 11241-503 between base of Q306 and grd; install a 1/2 bead P/N 19170-001 on same cap at base side of Q306. 3. Install a 1/2 bead P/N 19170-001 on C343 (Junction of C343 and R353). 4. Add Note 9 to indicate 1/2 ferrite bead.
		LM 37000-308	Same as above.
2507	7-1-68	J40000-101	1. Change R140 from 8.2K, 1/4W, 5% P/N 10010-822 to 3.9K, 1/4W, 5%, P/N 10010-392. 2. Change R142 from 22 ohm, 1/4W, 5% P/N 10010-220 to 47 ohm, 1/4W, 5%, P/N 10010-470. 3. Add a 820 PF Dipped Mica Capacitor* in parallel with R142, P/N 11077-821.*C136
		J40000-102	4. Change R332 from 8.2K, 1/4W, 5% P/N 10010-822 to 3.9K, 1/4W, 5%, P/N 10010-392. 5. Change R333 from 22 ohm, 1/4W, 5%, P/N 10010-220 to 47 ohm, 1/4W, 5%, P/N 10010-470. 6. Add an 820PF Dipped Mica Capacitor P/N 11077-821 across R333. (Ref. Des. C330

DATAPULSE
DIVISION OF DATAPULSE INCORPORATED

SERVICE BULLETIN
NO. 1-65

SEMICONDUCTOR REPLACEMENTS

(Applicable to all Datapulse Models except the Model 102.)

Datapulse makes extensive use of house labeled semiconductors, superseding or used in place of commercial equivalents. In most cases, these are procured against relaxed or actual commercial equivalent specifications, and commercial equivalents as listed below may, therefore, be used as replacements.

DATAPULSE TYPE NO.	DATAPULSE PART NO.	COMMERCIAL EQUIVALENT
Diodes:		
DP16-0	22164-000	1N3600
DP16-1	22164-001	1N3604
DP16-2	22164-002	HPA1003
DP19-0	22194-000	1N2070
DP19-1	22194-001	1N4002
DP19-6	22194-006	1N2071
Transistors:		
DP43-0	22435-000	2N984
DP46-0	22465-000	2N964A
DP46-1	22465-001	None*
DP59-0	22595-000	2N1132A
DP60-0	22605-000	2N2411
DP60-1	22605-001	None*
DP60-2	22605-002	2N2904 or 2N3133
DP60-3	22605-003	2N2894
DP60-4	22605-004	2N3209
DP60-5	22605-005	ft1702
DP60-6	22605-006	2N3640
DP60-7	12605-007	None*
DP63-0	22635-000	2N2369 or 2N2501
DP63-1	22635-001	2N3723
DP63-2	22635-002	None*
DP63-3	22635-003	2N2369A (Fairchild)
DP63-4	22635-004	2N3646 or MPS3646 or 2N2369A
DP63-6	22635-006	2N2270

*Replacements for the following items should be procured from Datapulse:

DP46-1 is selected from 2N2964A for high Beta.
DP60-1 is selected from 2N2894 for high V ceo.
DP63-2 is selected from 2N914 for tighter Beta tolerance.
DP60-7 is selected from DP60-1 for 25 volt breakdown.

1-10-68

10150 W. JEFFERSON BLVD., CULVER CITY, CALIFORNIA 90230 • TELEPHONE 213-871-0410/836-6100 • TWX 910-340-6766

WARRANTY

Datapulse Incorporated warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, transistors, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective.

Instruments returned under this Warranty will not be accepted at the Datapulse plant without prior authorization by a Datapulse representative or by the service manager of Datapulse Incorporated.

Datapulse Incorporated reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Datapulse Incorporated and Datapulse Incorporated neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Datapulse Incorporated instruments.

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